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WITH PLATE XI.

NEW HAVEN, CONNECTICUT.

1904

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(Thesis presented before the Faculty of Sciences, Paris, June, 1903.)

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2	" "	14	Aeschynite
3	" "	15	Fergusonite
4	" "	16	"
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6	Torbernite (Chalcolite)	18	Columbite (Niobite)
7	Autunite	19	" "
8	Thorite	20	" "
9	"	21	Tantalite
10	Orangite	22	"
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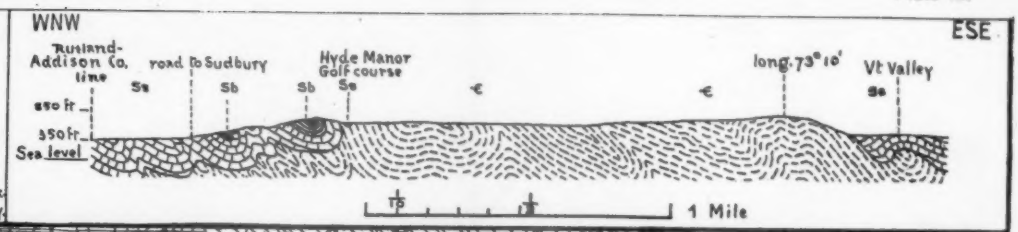
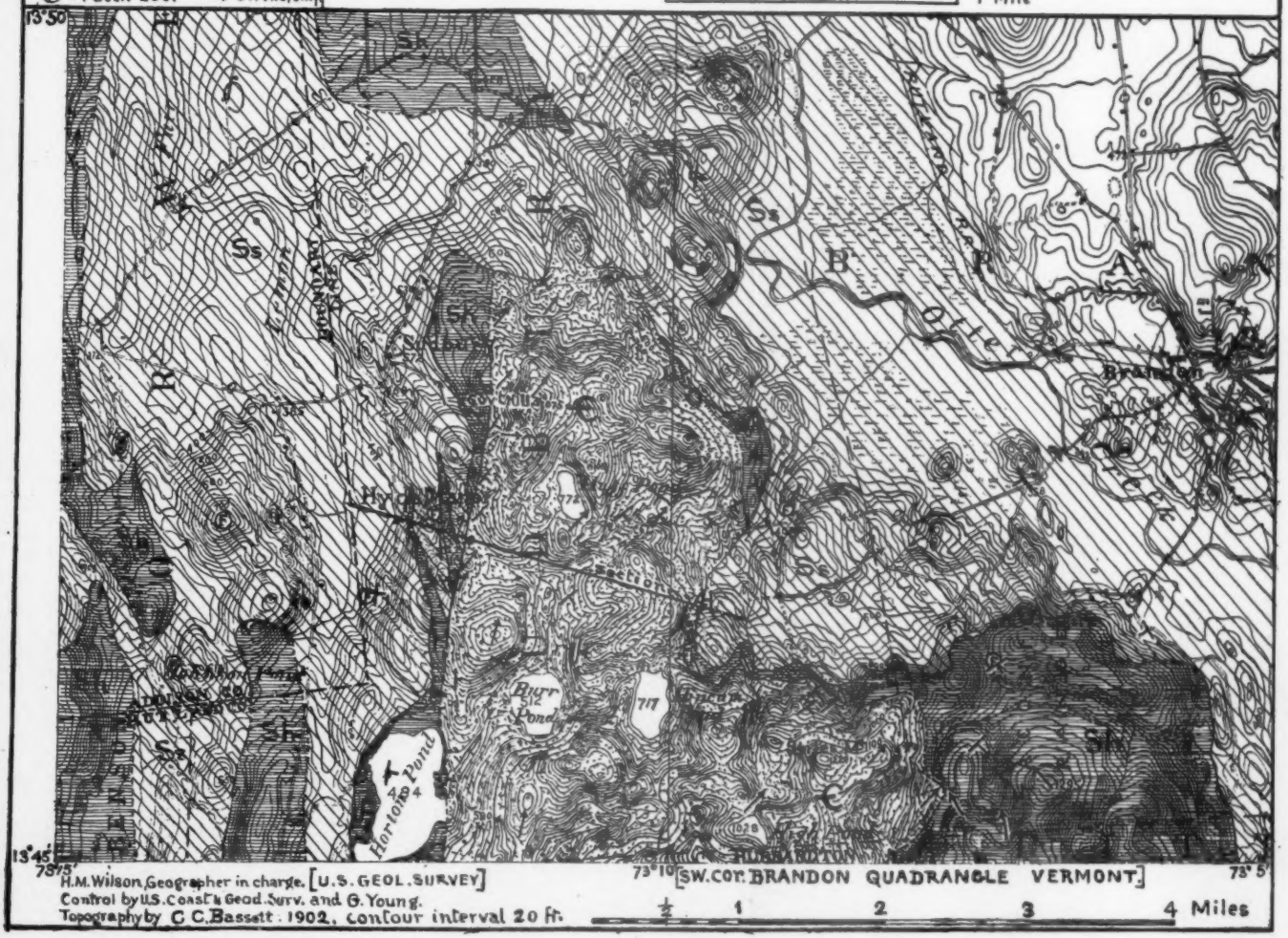
GEOLOGY of the North End of the TACONIC RANGE by T. Nelson Dale.

Sh Hudson Slate or Schist } Lower Silur.
Ss Stockbridge Limest }
€ Lower Cambrian Slate etc.
Ⓕ = Fossil Loc. ⟶ Strike, only.




43° 50'
Sh
Ss
Sh
Ss
Sb
Sh
Ss
Ss
Sh
Sh
Ss
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Sh
Ss
Ss
Sh

Plate XI.

ESE
long. 73° 10'
Vt Valley
1 Mile
Brandon
BRANDON QUADRANGLE VERMONT.
73° 5'
2
3
4 Miles

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

Art. XIII.—*The Geology of the North End of the Taconic Range;* by T. Nelson Dale.* (With Plate XI.)

The Taconic range lies west of the Green Mountain range, and extends from near Fishkill on the Hudson, N.N.E., to a point two miles south of Brandon in Rutland County, Vt., where, geologically speaking, it ends. It consists mainly of schists of Ordovician (Hudson) age, but as its northern part is more or less merged in a hilly belt of Cambrian slate and quartzite, flanking it on the west and extending four miles beyond it, the range may be said, physiographically at least, to extend almost to the Addison-Rutland County line and thus to have a total length of 200 miles.

In the published geological maps the north end of this range has been variously represented: (1) As consisting of a narrow tongue of Cambrian slate extending as far north as Cornwall, bordered on both sides by the schist of the Taconic range, which extends only to Sudbury village on the west and to a point S.W. of Brandon village on the east.†

(2) Of similar constitution but cut off between Whiting and Sudbury by a narrow strip of limestone connecting the limestone of the Vermont Valley with that of Orwell.‡

(3) Of a simple belt of Cambrian shale, etc., extending as far north as Weybridge.§

* Published by permission of the Director of the U. S. Geological Survey.

† Hitchcock and Hager: Report of the Geology of Vermont, vol. ii, pl. i, 1861.

‡ Dana (James D.): An account of the discoveries in Vermont Geology of the Rev. Augustus Wing, this Journal, vol. xiii, 1877. Map opposite p. 334 but modified by explanations on pp. 336, 339, and embodied in another map in vol. xiv, p. 36, in paper by same author entitled: Supplement to the account of the discoveries in Vermont Geology of the Rev. Augustus Wing.

A copy of Mr. Wing's original MSS, kindly loaned to the author of the present paper by Prof. H. M. Seely of Middlebury, contains a sketch map showing the topographic details of this E.-W. strip of limestone.

§ Walcott (Charles D.): The Taconic System of Emmons, and the use of the name Taconic in Geologic nomenclature; this Journal, vol. xxxv, pl. iii, 1888.

The north end of the Taconic range is an important locality, for the principal formations of the Taconic region, the Cambrian slate etc., the Stockbridge Limestone of the valleys, and the Ordovician schists of the Taconic range, all meet there within an area of a few square miles. The topographic map of the Brandon quadrangle, recently finished by the U. S. Geological Survey, has at last made careful exploration of this key locality possible; and the results amply justify the opinion that careful geological mapping with a reliable topographic base is the only method of settling intricate geological problems, and that this mapping should cover large areas, not only to prevent the overlooking of such crucial localities but also to show the wideness of their significance.

The writer and his assistants, Messrs. Louis M. Prindle and Fred H. Moffit, were engaged from 1894 to 1896 in going over and extending Mr. Charles D. Walcott's reconnaissance work in the Slate belt of Washington County, N. Y., and Rutland County, Vt. The results were published in 1899 accompanied by a geological map extending from lat. 43° to 43° 45′, and covering a strip from 10 to 12 miles wide along the west side of the Taconic range, covering in all about 720 square miles.* The fact was there brought out by Mr. Walcott's paleontological data and corroborated by our stratigraphical observations,† that in that region along many miles of intricate geological boundaries, where faulting is out of the question, the Lower Cambrian slates, with their Olenellus fauna, occur in apparently conformable contact with the Ordovician slates, shales, etc., containing Hudson Graptolites. Similarly, the Ordovician schists of the Taconic range were found to be in contact on the west with Lower Cambrian slates along a stretch of 50 miles south of the township of Sudbury, and at only two points (Hubbardton) was there any marked divergence in the strike of the two formations. This involved the anomalous absence of the Stockbridge Limestone along the west foot of that range, whereas on the east side of it the upper part of this formation (of Chazy and Trenton age) dips everywhere conformably under the overlying schists of the Hudson.

During the summer of 1903, the north end of the Taconic range and the adjacent country were somewhat carefully, although not exhaustively, explored by the writer assisted by his son. The exposures were found to be sufficiently numerous to show the mutual relations of the several formations, and the results

* The Slate belt of Eastern New York and Western Vermont. by T. Nelson Dale, 19th Ann. Rept. U. S. Geol. Survey, 1889, Part III, pp. 153–307. Map, pl. xiii. Reviewed in this Journal, vol. clix, p. 382.

† See ibid., pl. xiii and pp. 290–295, on the relation of Cambrian and Ordovician.

are shown in the accompanying map and section, Plate XI.* The map shows a central tongue of Cambrian slate, quartzite, etc., bordered both on the east and west by narrow strips of Ordovician schist or slate, and, in its southern and eastern side, adjacent to a larger mass of Ordovician schist, two miles wide, which constitutes the north end of the Taconic range proper. This tongue of Cambrian is bordered on the north and at several points on the sides by the Stockbridge Limestone. The mass of Ordovician schists, shown at the upper edge of the map, which continues, with a possible interruption east of West Cornwall, 12 miles north to Middlebury and even beyond, is cut off, as was first shown by Wing, from the slate and schist on the south by the Stockbridge Limestone, and is not even indirectly connected, as one of his maps showed, with the Ordovician schists of the Taconic range. The Ordovician part of the Stockbridge Limestone, as shown by fossil localities, touches the Cambrian slates on three sides. The Cambrian part† of that formation, not indicated on the map, crops out near Brandon village, and extends north and east of it, forming a longitudinal belt between the Lower Cambrian quartzite (Vermont Formation) of the Green Mountain range on the east, and the Ordovician part of the Stockbridge Limestone on the west.

The determination of the age of the slates and schists of the north end of the Taconic range is based upon the following evidence: The Lower Cambrian age of the central slate mass in Sudbury is shown by the occurrence at intervals, as far north as the northern slope of Government Hill, a mile east of Sudbury Church, of a slightly ferruginous, calcareous, quartz sandstone, typical of that formation in Washington County, N. Y.;‡ by the fact that typical Lower Cambrian roofing slates are being quarried a half mile north of Stiles Mountain in Sudbury;§ by the presence of six localities of Lower Cambrian fossils in the same belt within two and one-half miles south of the southern edge of the area shown on the map; by the general petrographic charter (massive quartzite, quartzose slates, greenish and purplish roofing slates, calcareous sandstone) of a large part of the area designated as Cambrian. In places, however, petrographic distinctions fail, as the slates become schistose and resemble the Ordovician schist. The Ordovician age of the schist and slate masses bordering the Cambrian (Sh on map) is shown by the presence of red roofing slates, typical of the Hudson,‖ a mile S.S.E. of Hyde

* As to this map: those parts of the geological boundaries which are more or less uncertain are shown in dotted lines to distinguish them from those which are well established and indicated in full lines. The round black dot a half mile E.S.E. of Hyde Manor represents what seems to be an outlier of Ordovician limestone, about 70 × 40 ft. across, resting upon the Cambrian slates.

† Whether this Cambrian includes some Beekmantown is not yet determined.

‡ Horizon E of the slate belt. Op. cit. table facing p. 178.

§ Locality shown on map by crossed hammers.

‖ Horizon Irs of Slate belt. Op. cit. table facing p. 178.

Manor, and three-fifths of a mile E.S.E. of Sudbury Church, and again, apparently, in a badly weathered condition, one and one-fourth mile E.N.E. of Huff pond on the east side of the Cambrian belt; by the presence of typical schists of the Taconic range at the most northern summit of that range, three miles S.S.W. of Brandon village (elevation 1295 ft.); by indications of Ordovician fossils (Crinoid stems, etc.) in a small mass of included limestone, a mile N.N.W. of that hill;* and by the presence of graphitic sericite schist, so common at the base of that schist formation in Vermont and Massachusetts, in the small strip N.E. of Hincum pond. These age determinations are furthermore corroborated by a dominant, though not universal, N.E. strike in the Cambrian slates, and an almost equally prevalent N. or N.15W. or N.N.W. strike in the Ordovician schists and in the underlying limestone.

The structural relations of the formations are shown by symbols on the map and by the section above it, Plate XI. It will be noticed that the parallelism between the strike of the Cambrian and Ordovician, already referred to as characteristic of the slate belt to the south, still persists on the west side of the Cambrian slates near Horton and Burr ponds; but within a mile of Hyde Manor a marked divergence begins to appear, the Cambrian striking more or less N.E., the Ordovician N.15–25W.;† and this continues to the extreme N. end of the mass. The prevalent strike of all the rest of the Cambrian area is about N.E.; exceptionally, however, as east of Huff pond, possibly owing to a minor pitching fold or a small fault, a few N.W. strikes appear, and there may be others. The Ordovician schists of the east side of the Cambrian tongue are likewise marked by a N.15–25W. strike. This, indeed, is the trend and strike of the Taconic range as far south as West Rutland, eleven miles from the south edge of the map. A similar strike also appears in the limestone of the valley towards Brandon. But to this N.N.W. strike of the Ordovician there is also an exception, for the schists of the west side of the schist mass E. and N.E. of Stiles Mountain strike N.E. and a similar strike appears at several points in the limestone embayment east of the Cambrian. The cause of these N.E. strikes in the Ordovician is not apparent, unless it be a system of transverse folds like that occurring on the north end of Mount Anthony in Bennington. A mile N.E. of the Cambrian point the limestone resumes the normal strike of the Green Mountain region, and this recurs again at Leicester Junction, two miles north of the map. To all this should be added that the Cambrian slates have here and there a secondary cleavage foliation, striking N.15W., i. e. parallel to the strike of the bedding of the Ordovician schist.

* Locality marked F on map. † Exceptionally also N.—N.15E.

The section is drawn so as to cross contacts where the unconformity is manifest but owing to insufficiency of data, the folds represented in the Cambrian portion away from the contacts are largely hypothetical. The straightness of the Cambro-Ordovician boundary on the west side may be the result of faulting; but as the unconformity is quite as great at several points on the east side, where faulting is improbable, and as N.E. strikes are quite as characteristic of the center as of the sides of the Cambrian tongue, it is evident that faulting is not the cause of the unconformity. If it exists, it is between rocks which were already unconformable. Such a fault would have to be a reversed one and would hade to the east, bringing the Cambrian beds to overlie the Ordovician ones. The section has been constructed to show the relations without the faulting, although such faulting is regarded as quite possible. That the limestone once covered at least the western border of the Cambrian, is probable from the presence of the small outlier in the Hyde Manor Golf grounds, already referred to and shown in the section. This limestone strikes N.10E., as does also the nearest Ordovician limestone east of it, but the Cambrian slate about it strikes N.40E.

The interpretation of the facts set forth in the map and section is this: The Lower Cambrian slate formation, which is now regarded as the off-shore equivalent of the quartzite of the Green Mountain range (Vermont Formation of U. S. G. S. Monograph XXIII), was folded at the close of Lower Cambrian time and in places, raised above sea level, forming one or more islands in the Champlain oceanic arm. The direction of this Cambrian folding was generally the same as that of Ordovician time, known as the Green Mountain movement, but at this point the axes of these Cambrian folds, for some reason, had a more easterly course, resulting in N.E. strikes. A very gradual depression, beginning during the latter part of Stockbridge Limestone time and continuing into Hudson time, caused the deposition of some of the limestone and of all the schist upon these former islands of Lower Cambrian rocks. This, as suggested to the writer by Professor C. R. Van Hise, resulted in some places in an overlapping of the limestone by the Hudson schist and slate, and in others, in the deposition of the schist and slate immediately upon the Cambrian slates. This overlap, in particular, accounts for the absence of the Stockbridge Limestone for 50 miles along the west side of the Taconic range. In 1898* the writer sought to explain this by a local change from calcareous to argillaceous sedimentation during Stockbridge Limestone time, as had been proven by Pumpelly and

* Op. cit. Slate belt, etc., p. 295, last paragraph, to p. 297.

Wolff to have occurred on Hoosac Mountain.* That explanation of the relations about the Taconic range is now shown to be erroneous.

Then came the Ordovician folding which, here and as far south as West Rutland, produced N.15–25W. strikes, principally, and which may have produced the N.15W. secondary cleavage in the Cambrian slates, and must also have otherwise more or less modified the Cambrian structure as well as the Cambrian surface. The central part of the section shows the Cambrian folding, and the ends of it the overlapping and the Ordovician folding. Denudation through long geological periods must account for the presence of only shred-like remnants of the great mass of Ordovician argillaceous sediments and for the severance of the northern extension of the schist from the Taconic range, and, generally, for the exposure of the Stockbridge Limestone. The salient fact is the unconformity between the Lower Cambrian and the Ordovician, which is masked in the slate region of Washington Co., either by the parallelism in the strike of the two foldings or by the effect of the later one upon the earlier, but which was accentuated at the north end of the Taconic range by the original divergence in the strike of the two periods and is still shown in the dips. This unconformity thus fully corroborates, stratigraphically, the time break shown, paleontologically, by Mr. Walcott's fossil localities.†

Although the Taconic controversy was settled long ago, and has ceased to be of other than historical interest, as it was shown by Dana, Walcott and the authors of Monograph XXIII, that Ordovician rocks had been included by Ebenezer Emmons in his Taconic System owing to the overlooking of faults, the mistaking of cleavage for bedding and insufficient exploration of the areal relations, yet it is remarkable that at this late day it should appear that his contention that there was an extensive formation, marked by a peculiar fauna, now known as Lower Cambrian, unconformably related both to the underlying gneisses (pre-Cambrian) and to the overlying Lower Silurian rocks (Hudson, etc.), should be confirmed, at least for a part of the Taconic region, for no trace of the unconformity shown by this paper has yet been found along the Green Mountain border. During the Taconic controversy, however, conformable succession of the Cambrian and Ordovician beds was supposed by the opponents of Emmons to hold for the entire region.‡

* Geology of the Green Mountains in Massachusetts, by Raphael Pumpelly, J. E. Wolff, and T. Nelson Dale. Monograph, U. S. Geological Survey, XXIII, 1894, pp. 14–18, 104.

† Op. cit. Slate belt, pp. 163, 166.

‡ Rogers (Henry D.), this Journal (1), vol. xlvii, D., p. 152, 1844; Walcott (Charles D.), op. cit. this Journal, vol. xxxv, 1888, p. 320.

Pittsfield, Mass, December, 1903.

ART. XIV. — *Notes on some California Minerals;* by WALDEMAR T. SCHALLER.

HALLOYSITE.

THE pink clay occurring at Branchville, Ct., has been shown* to be montmorillonite, while that occurring at Norway, Me., has proven† to be cimolite. That from the lepidolite mine near Pala, San Diego Co., California, differs from both of the New England clays, being comparable with halloysite.

At Pala, the halloysite occurs in large seams, often several inches thick, and extending many feet in length. The clay is somewhat moist, but quickly dries to a crumbling mass when taken out of the mine. In color it is rather deeper pink than the Norway cimolite and occasionally is somewhat translucent. It readily crumbles to a fine powder when placed in water. The material analyzed had been drying in the air for over three months.

The results of analysis are:

SiO_2	43·62
Al_2O_3	35·55
Fe_2O_3	·21
MnO	·26
CaO	1·02
MgO	·19
Li_2O	·23
Na_2O	·19
K_2O	·03
H_2O (107°)	6·63
H_2O (ab. 107°)	12·25
TiO_2	none
	100·18

The iron was determined as Fe_2O_3, FeO not being tested for. The analysis agrees well with the formula

$$H_4Al_2Si_2O_9 + H_2O.$$

AMBLYGONITE.

The occurrence of amblygonite at the lepidolite mine at Pala, California, has already been noticed, and a somewhat fuller description of the mineral is here given. A large deposit has been uncovered and the indications seem to show that it is merely a small part of an extensive body of massive

* This Journal, xx, 283, 1880. † Ibid., xxxii, 355, 1886.

amblygonite. The mineral usually occurs pure; very rarely small amounts of lepidolite are present with it. Frequently broad cleavage faces with irregular outlines can be seen. The color is white and in thin pieces the mineral is translucent. It fuses easily, coloring the flame red, and in powder is difficultly decomposed by sulphuric acid.

An analysis of a specimen kindly presented by Mr. G. F. Kunz gave the writer the following results:

P_2O_5	48·83
Al_2O_3	33·70
Fe_2O_3	·12
MnO	·09
MgO	·31
Li_2O	9·88
Na_2O	·14
H_2O	5·95
F	2·29
TiO_2	none
	101·31
Less O	·96
	100·35

Regarding fluorine and hydroxyl as isomorphous, in the specimen analyzed the latter greatly predominates over the fluorine. The water was determined by igniting the mineral with lead oxide, previously heated nearly to fusion. Three determinations gave the loss of weight, due to the escape of water, as 5·89, 6·01, 5·95 per cent. The loss of the mineral on ignition was 8·03 per cent, equalling the sum of the water and fluorine content.

Boothite.

A specimen of a pale blue copper sulphate was collected at the copper mine near Campo Seco, Calaveras Co., California, by Mr. James Wise, and kindly presented to the writer for investigation. The pale blue color suggested that the mineral might be boothite instead of the more frequently occurring chalcanthite. The results of a chemical analysis have shown that the mineral is boothite, thus affording a second locality for this interesting mineral. Careful quantitative determinations of hydrous copper sulphates will probably show that the heptahydrate is not so rare as may be supposed.

The mineral from Campo Seco occurs massive, showing no crystalline structure. The average of several determinations afforded the following results:

			Ratio.	
CuO	26·13		1·00	
FeO	·81		·03	
MgO	·64		·05	
SO_3	27·25		1·04	
H_2O (110°)	36·76	41·67	6·22	7·06
H_2O (ab. 110°)	4·91		·84	
Insol.	3·96		----	
	100·46			

Formula, $CuSO_4.H_2O + 6H_2O$.

A careful determination of the specific gravity of the mineral gave (21° C.) 1·944. This being much lower than the value obtained (2·1) on the boothite from Leona Heights, a redetermination of the latter was made on purer material collected since the publication of the first results.* This gave, as an average value, the figure (22° C.) 1·935. The average of these two determinations, or 1·94, is probably very near the true value for the specific gravity of boothite.

Pisanite.

A small specimen of massive pisanite from Gonzales, Monterey Co., California, was analyzed some time ago and the results are here presented. The quantity of material available for analysis was very small and the determinations do not claim any great accuracy. About 6 per cent of insoluble matter has been deducted and the results recalculated to 100 per cent.

		Ratio.	
CuO	7·56	·27	·89
FeO	15·85	·72	
SO_3	30·74	1·08	
H_2O	45·85	7·18	
	100·00		

The analysis approximates to the formula $CuO.2FeO.3SO_3.21H_2O$.

In the following table, all available analyses of pisanite are tabulated, and one can readily see that there is no definite ratio between the copper and iron. The formula is then written $(Cu,Fe)SO_4.7H_2O$, pisanite being an isomorphous mixture of melanterite and boothite. All the analyses are calculated to 100 per cent.†

* Minerals from Leona Heights, Alamada Co., California, by W. T. Schaller, Bull. Dept. Geol. Univ. of Cal., vol. iii, No. 7.

† Anal. No. 1, theoretical comp. of melanterite, $FeSO_4.7H_2O$; No. 2, Schaller, anal. quoted above; No. 3, Schaller, Bull. Dept. Geol. Univ. of Cal., vol. iii, No. 7; No. 4, Hintz, Zeit. Krys. ii, 309; No. 5, Hillebrand, Bull. U.S.G.S., No. 220, p. 105; No. 6, see No. 3; No. 7, Pisani, Comptes Rendus, 1859, xlviii, 807; No. 8, see No. 3: Nos. 9 and 10, Herz, Zeit. Krys. xxvi, 16; No. 11, theoretical comp. of boothite, $CuSO_4.7H_2O$.

No.	1	2	3	4	5	6
CuO	....	7·56	9·17	10·07	12·61	15·52
FeO	25·86	15·85	16·37	(16·15)	14·14	12·14
SO_3	28·80	30·74	29·00	28·84	28·44	27·82
H_2O	45·34	45·85	45·46	(44·94)	44·81	44·52
	100·00	100·00	100·00	100·00	100·00	100·00

No.	7	8	9	10	11
CuO	15·56	17·45	17·64	18·81	27·85
FeO	10·98	10·18	9·62	8·51	....
SO_3	29·90	28·43	28·27	27·93	28·02
H_2O	43·56	43·94	44·47	44·75	44·13
	100·00	100·00	100·00	100·00	100·00

Quartz Pseudomorph after Apophyllite.

At the Datolite and Pectolite* locality near Fort Point, San Francisco, Cal., a small group of crystals was found which were at first taken to be apophyllite. However, as the crystals proved to be infusible, a more extended investigation of the mineral was made.

The crystals, from one to three mm. in diameter, appear cubic with the corners truncated by small faces. Measurements of the best crystals showed that they are tetragonal and that they agree in angles with those of apophyllite. The forms present are the base, prism of the second order and the unit pyramid of the first order. The prism faces are vertically striated and faces of the other two forms are also rarely somewhat striated.

By trial it was found that hydrochloric acid does not attack the crystals, so the associated calcite was easily removed and pure material for analysis obtained. The crystals are opaque and no optical determinations could be made.

The analysis gave the following figures, showing that the crystals are now, chemically, essentially silica with various impurities.

SiO_2	90·58
Al_2O_3	1·58
CaO	1·87
MgO	2·20
H_2O	4·32
	100·55

* Mineralogical Notes by A. S. Eakle, Bull. Dept. Geol. Univ. Cal., vol. ii, No. 10.

Laboratory of the U. S. Geological Survey, November.

ART. XV. — *Crystallographical and Chemical Notes on Lawsonite;* by W. T. SCHALLER and W. F. HILLEBRAND.

CRYSTALS of lawsonite are very simple in their combinations, the common forms being the prism, base and brachydome. Two habits occur; tabular crystals with {001} and {110} and crystals with the forms {110} and {011}. The brachypinacoid and the brachydome {041} also occur. A large number of crystals from the typical locality in Marin County, California, were collected by the writer and carefully examined with a hand lens for any additional forms. Only two new forms were determined.

The forms observed on the six crystals measured are:

$c = 0 = 001$	$d = 01 = 011$
$b = 0\infty = 010$	$e = 04 = 041$
$m = \infty = 110$	$r = 2 = 221$
	$s = 3 = 331$

The angles measured, with those calculated for these forms, are quoted in the table following:

No.	Letter.	Symbol.		Measured.		Calculated.	
		Gdt.	Miller.	ϕ	ρ	ϕ	ρ
1	c	0	001	----	0° 02′	----	0° 00′
2	b	0∞	010	0° 00′	90 00	0° 00′	90 00
3	m	∞	110	56 22	"	56 22	"
4	d	01	011	0 09	36 36	0 00	36 27
5	e	04	041	0 00	71 18	"	71 18
6	r	2	221	56 27	69 10	56 22	69 27
7	s	3	331	56 22	76 21	"	75 58

The new pyramid $r = 2 = \{221\}$ is present on two crystals, the faces giving good reflections. Fig. 1 shows one crystal on which this form occurs.

The new pyramid $s = 3 = \{331\}$ is present on only one crystal and but one face of the form occurs. The relative size of the face is about the same as that of the preceding pyramid. The reflection was fair.

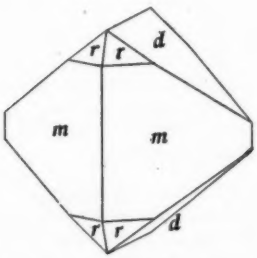
The brachydomes are usually deeply striated, rendering it difficult to determine with certainty any domes present. On two crystals, reflections were obtained from two faces, measurements of which agree with the angles calculated for the form {034}. The form is rather uncertain and is not included with the others.

Measured.			Calculated.	
ϕ	ρ		ϕ	ρ
0° 23′	28° 07′	−14′	0° 00′	28° 59′
0 00	28 07			

The combinations observed on the crystals measured are shown in the following table:

Cryst. No.	*c*	*b*	*m*	*d*	*e*	*r*	*s*
1	--	--	*m*	*d*	--	*r*	--
2	--	*b*	*m*	*d*	--	--	*s*
3	--	--	*m*	*d*	--	*r*	--
4	*c*	*b*	*m*	*d*	*e*	--	--
5	--	*b*	*m*	*d*	--	--	--
6	*c*	--	*m*	*d*	*e*	--	--

1



The following table is a calculation of the two new forms corresponding to the tables given in Goldschmidt's Winkeltabellen.

No.	Letter	Symbol	Miller	ϕ	ρ	ξ_0	η_0	ξ	η	x (Prism) $(x:y)$	y	$d = tg\,\rho$
6	*r*	2	221	56° 22′	69° 27′	65° 45′	55° 54′	51° 13′	31° 14′	2·2204	1·4770	2·6667
7	*s*	3	331	"	75 58	73 17	65 42	53 53	32 30	3·3306	2·2155	4·0001

Material carefully purified by the Thoulet solution followed by repeated electromagnetic extraction, and having then a specific gravity of 3·121 at 25°, gave the following results of analysis:*

* Concerning this purified material, Dr. Ransome reports as follows: "I should say the material is as pure as it is possible to get it. The grains are all lawsonite, but vary in individual purity. Some are perfectly clear. Others have minute inclusions, which appear in most cases to be solid particles but are too minute for identification. One of them, however, was suggestive of rutile. Some of the grains are slightly clouded with a yellowish stain which the microscope is unable to resolve into distinct particles. There are apparently a few fluid inclusions also."

		Mol. Ratio	Calc. for the formula $H_4CaAl_2Si_2O_{10}$
SiO_2	38·45	1·98	38·34
TiO_2	0·38		
Al_2O_3	31·35	0·97	32·44
Fe_2O_3	0·86		
FeO	0·10		
MnO	faint trace		
CaO	17·52	1·00	17·80
MgO	0·17		
K_2O	0·23		
Na_2O	0·06		
H_2O (ignition)	11·21	1·95	11·42
	100·33		100·00

Titanium is not considered in the ratio because probably present as an inclusion of rutile or titanite. If the latter, the ratio would perhaps approximate still more closely to the theoretical than it does. The agreement with the formula deduced by Ransome and Palache from their rather widely differing analyses is very satisfactory. The behavior of the mineral before the blowpipe is somewhat different from that given by those authors, or rather their statement needs amplification. On first applying the flame, a splinter appears to fuse easily as stated, and there is formed a blebby glass, or on larger splinters a porous sinter, but this fusing is only momentary, and it requires the highest heat attainable, under which the fragment emits quite an intense light, to produce a further softening and rounding of the edges. If a rather large splinter is held in the flame of the blowpipe, or in a small flame of a blast lamp, a very sudden and marked exfoliation is observed, but even the extruded points and edges do not fuse completely in the highest attainable heat. The semi-fused surface, however, appears on cooling dark and sometimes nearly black where the heat was most intense. If care is taken, in producing this exfoliation, to apply the flame but for a moment, it has been noticed that a singularly shaped excrescence may shoot out from a point of the surface.

Laboratory of the U. S. Geological Survey, November.

Art. XVI.—*A Determination of Nitrites in Absence of Air;* by I. K. Phelps.

[Contributions from the Kent Chemical Laboratory of Yale University—CXXIV.]

Dunsten and Dymond* have recommended the use of an evacuated flask for the estimation of nitrites by the action of potassium iodide in acid solution. Under these conditions, the nitrous and hydriodic acids interact to produce nitric oxide (which must be kept from contact with gaseous oxygen) and iodine which is determined by decinormal sodium thiosulphate. As objections to the process may be cited the necessity of getting an absolutely gas-tight, rubber-jointed apparatus and the restriction put upon the size of the flask by the two considerations of withstanding the atmospheric pressure when evacuated and yet being thin-walled enough to allow of the ready heating of the flask. A practical test of a slight modification of the device already used in the determination of nitric acid† for getting an inert atmosphere proves to obviate these difficulties and to leave little to be desired in point of accuracy.

The apparatus used was the same as in the estimation of nitric acid already referred to above. It consisted of a boiling flask of 250$^{cm^3}$ capacity closed with a rubber stopper carrying in its two perforations the inlet and exit tubes. A stoppered funnel of 50$^{cm^3}$ capacity with its tube constricted at its lower end was used as an inlet tube; and a glass tube of ·8^{cm} internal diameter, enlarged just above the stopper to a small bulb (to prevent mechanical loss of the solid contents of the flask during the boiling) and bent twice at right angles, served as an exit tube. The flask was supported in the usual manner at a convenient height to allow of heating with a Bunsen burner placed beneath and the exit tube was made of a sufficient length to reach to the surface of some mercury contained in a test tube to the depth of about three centimeters.

The analysis was made as follows: An amount of standard arsenious acid solution, slightly in excess of that required to take up the iodine to be set free later by the nitrous acid, and 25$^{cm^3}$ of a concentrated solution of sodium carbonate were placed in the flask. The stem of the dropping funnel was completely filled with water, the rubber stopper inserted tightly, and the contents of the flask boiled until all air was expelled—a process requiring an active boiling of 5–8 minutes. The flame was then removed, the exit tube plunged deep into the mercury by changing the position of the flask on its wire gauze—which is particularly easy if the gauze is well depressed at

* Pharm. Jour. [3], 19, 741. † This Journal, xiv, 440 (1902).

the center and the flask placed well up on the higher part in the preceding operation—and sulphuric acid (1–4) sucked in through the funnel tube as the flask cooled, the cooling to the room temperature being hastened by standing the flask in a dish containing ice and water. In all, 7^{cm^3} of sulphuric acid were added, this amount having been found by previous experiment to be nearly but not quite enough to neutralize the sodium carbonate used and also having been found to yield a little more carbon dioxide than the apparatus can hold at the atmospheric pressure. As soon as the diminished pressure in the apparatus was too weak to suck in the acid, the position of the flask was again changed on the wire gauze so that the exit tube was raised out of the mercury into the layer of water which had condensed during the preceding boiling and which then served to trap the apparatus from the outside air. After the acid had been added and had been washed in carefully, the nitrite solution to be analyzed containing 2 grms. of pure potassium iodine was introduced into the flask through the funnel and this was followed by sulphuric acid (1–4) in sufficient amount (5^{cm^3}) to render the contents of the flask acid in reaction. Potassium bicarbonate was then added in concentrated solution to alkaline reaction or until the free iodine had been taken up, the mixture boiled for about five minutes to expel the nitrogen dioxide, cooled, and titrated to color with decinormal iodine in the presence of starch paste. In making the various additions of liquid to the flask, care was necessarily taken that no air was introduced with the liquid. Table I records experiments made in this manner upon a solution of commercial sodium nitrite, standardized by treatment with potassium permanganate and oxalic acid in acid solution according to the procedure of Kinnicut and Nef.*

TABLE I.

	$NaNO_2$ taken. grm.	Oxygen value of As_2O_3 taken. grm.	Oxygen value of As_2O_3 found. grm.	Error on Oxygen. grm.	Error on $NaNO_2$. grm.
1	0·0958	0·01200	0·00064	0·00025 +	0·0011 +
2	0·0958	0·01200	0·00066	0·00024 +	0·0010 +
3	0·1916	0·03200	0·00965	0·00017 +	0·0007 +
4	0·1916	0·03200	0·00965	0·00017 +	0·0007 +
5	0·3832	0·05600	0·01120	0·00043 +	0·0018 +
6	0·3832	0·05600	0·01118	0·00045 +	0·0019 +
7	0·6716	0·08000	0·00160	0·00076 +	0·0033 +
8	0·6716	0·08000	0·00158	0·00078 +	0·0034 +
9	0·1916	0·03280	0·01003	0·00062 +	0·0027 +

* Amer. Chem. Jour., v, 388 (1883).

The experiment numbered 9 is included to show a fact found early in the investigation, namely, the necessity of boiling out the nitrogen dioxide before titrating the residual arsenious acid. It was made like 3 and 4 above up to that point, when in stead of boiling out the nitrogen dioxide, cooling, and titrating, it was treated with a slow stream of air bubbling through for fifteen minutes and then titrated. Evidently the nitrogen dioxide in oxidizing affects the arsenious acid slightly.

When the sulphuric acid is being added to the alkaline solution containing the arsenite, iodide, and nitrite, iodine is set free locally but is at once taken up by the alkaline arsenite, so that finally, when the acid reaction is reached, there is only a small amount of it free, no matter how much nitrite may have been used. This condition reduces to a minimum the possibility of a loss of iodine by volatilization.

As might be anticipated, the two processes show slightly different results, the process outlined above tending to give results in excess of the theory on account of the action of dissolved oxygen, while that of Kinnicut and Nef should show a deficiency as compared with theory, since the loss of nitrogen oxides is evidenced by the odor when even a very dilute solution of a nitrite is acidified.

ART. XVII.—*The Use of Ferrous Sulphate in the Estimation of Chlorates and Bromates;* by I. K. PHELPS.

[Contributions from the Kent Chemical Laboratory of Yale University—CXXV.]

IN a recent article,* a method for the titrimetric estimation of nitric acid or nitrates was described. It consisted, briefly, in the measurement of the amount of ferrous salt oxidized in the reduction of the nitric acid to nitric oxide by an excess of ferrous sulphate in the presence of hydrochloric acid. The value of ferrous sulphate as a reducing agent in analytical processes has been long recognized on account of its ready availability, the high degree of precision with which it may be determined, and the extreme slowness with which it is oxidized by atmospheric oxygen. This last fact was clearly shown by Peters and Moody† for solutions which had been allowed to stand until all active oxygen, dissolved in the water, or otherwise present, had produced its effect. The author was surprised to find that, in boiling such solutions in the open air and cooling with stirring in running water, no distinctly perceptible change could be noted, although the oxidation from day to day was plainly evident.

Carot‡ has suggested the use of ferrous sulphate for determining the oxygen in hypochlorites and chlorates in admixture with chlorides but gives no evidence to show the degree of accuracy of the process. Table I records experiments made with the purest potassium chlorate of commerce to test this point. The dry salt was weighed out, treated with an excess of standardized ferrous sulphate solution $\left(\text{approximately } \frac{n}{5}\right)$, and with 15^{cm^3} of sulphuric acid (1 : 4). This mixture was brought to the boiling point in a trapped flask, cooled to room temperature by immersion in running water, diluted to a volume of 600^{cm^3}, and, after the addition of 1–2 grms. of manganous chloride, titrated to color with standard potassium permanganate solution.

TABLE I.

$KClO_3$ taken. grm.	Oxygen value of ferrous salt taken. grm.	Oxygen value of ferrous salt found. grm.	Error on $KClO_3$. grm.
0·0500	0·02756	0·00814	0·0004 —
0·0500	0·02739	0·00781	0·0000 ±
0·1000	0·04934	0·01024	0·0002 —
0·1000	0·04951	0·01043	0·0002 —
0·2000	0·09086	0·01247	0·0002 +
0·2000	0·09078	0·01277	0·0008 —
0·5000	0·20552	0·00993	0·0006 —
0·5000	0·20543	0·00980	0·0005 —

* This Journal, xiv, 440 (1902). † This Journal, xii, 369 (1901).
‡ Compt. Rend., cxxii, 449.

Table II records similarly experiments made upon a sample of thrice crystallized potassium bromate which was prepared by acting on potassium hydroxide with bromine evolved from pure potassium bromide by sulphuric acid and manganese dioxide. The experiments were performed like those with the chlorate, described above, except that the excess of ferrous salt used in the reduction was determined by decinormal iodine in alkaline solution instead of by permanganate in acid solution. The solution was cooled after boiling, was nearly neutralized with a concentrated solution of sodium carbonate, and was then treated with 2–3 grms. of Rochelle salt in solution and an excess of decinormal iodine solution. The mixture was made alkaline with an excess of potassium bicarbonate solution, starch paste added, the starch blue bleached with decinormal arsenious acid, and, finally, the excess of this last titrated to color with iodine.

TABLE II.

$KBrO_3$ taken. grm.	Oxygen value of ferrous salt taken. grm.	Oxygen value of ferrous salt found. grm.	Error on $KBrO_3$. grm.
0·0500	0·01776	0·00357	0·0006—
0·0500	0·01770	0·00336	0·0001—
0·1000	0·03792	0·00942	0·0008—
0·1000	0·03792	0·00922	0·0001—
0·2000	0·06321	0·00576	0·0000±
0·2000	0·06321	0·00580	0·0002—
0·5000	0·15670	0·01342	0·0013—
0·5000	0·16212	0·01870	0·0008—

An inspection of the results shows that the processes may be justly considered as accurate for analytical purposes—especially so when one considers that they measure only the oxygen in the salt analyzed, which is 39 per cent for potassium chlorate and 28 per cent for potassium bromate.

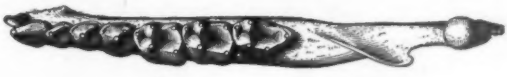
Art. XVIII.—*Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. Wortman.

[Continued from vol. xvii, p. 140.]

On the Affinities of the Omomyinæ.

As I have already fully stated, my arrangement of this group of Primates under the Paleopithecine division of the Anthropoidea is only provisional. The incompleteness and frag-

135



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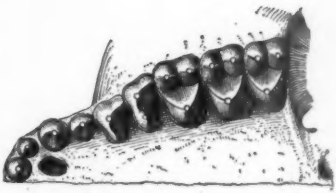


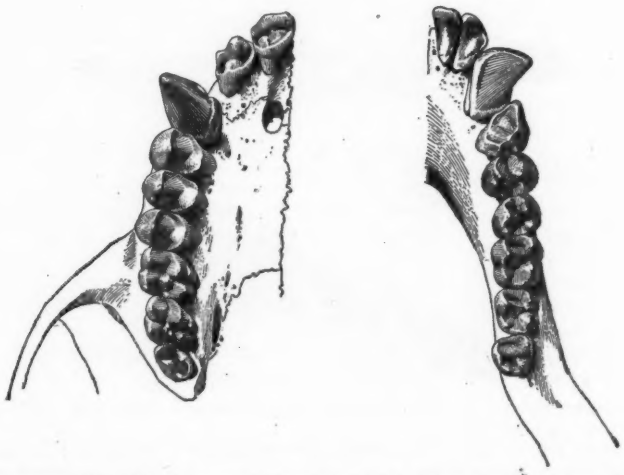
Figure 135.—Lower jaw of *Tarsius spectrum;* crown view; two and one-half times natural size.

Figure 136.—Upper teeth of *Tarsius spectrum;* crown view; two and one-half times natural size.

mentary condition of the remains of all the species thus far known precludes the possibility of determining their affinities and position with any great degree of exactness. It has been pointed out that the dentition of the lower jaw, and presumably that of the upper jaw also, in all the species in which it is definitely known, is represented by two incisors, a canine, three premolars, and three molars. This number differs from that of *Tarsius*, figure 135, in the presence of an additional incisor, there being only a single pair in the lower jaw of that genus. The structure of the lower molars and premolars accords well, moreover, with that of *Tarsius*, which undoubtedly represents a very generalized pattern among the Primates, and one from which it is possible to derive all the more complex types of the higher forms. In the structure of the superior molars, all the species of the Omomyinæ have apparently advanced beyond

the *Tarsius* stage, figure 136. This is seen in the continuation of the cingulum forward, around the internal face of the crown, and the development of a distinct cingular cuspule internal to the main antero-internal cusp. In the two external roots of the fourth superior premolars, however, the species of the Omomyinæ, as far as known, agree with *Tarsius*. This is very probably a generalized character, also, since there is very strong presumptive evidence that the single external root of the third and fourth premolars, common in the higher apes, is the result of degeneration caused by the shortening of the face.*

137 138



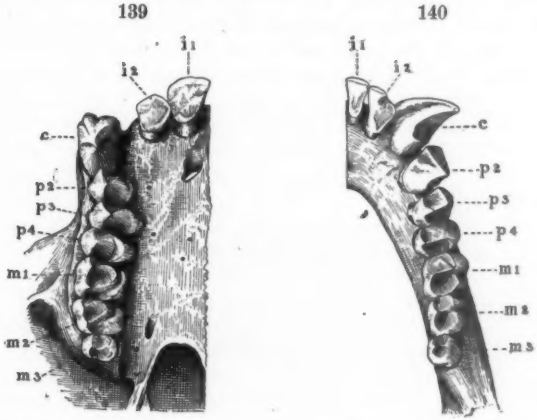
FIGURES 137, 138.—Upper and lower teeth of *Cebus apella*; crown view; three halves natural size.

The final determination of the exact relations of these forms to *Tarsius* must await the discovery of the lachrymal region, as well as of the structure of the limbs and feet.

It is proper, however, to call attention in this connection to some striking resemblances which this group exhibits to certain of the South American apes, notably the capuchins and squirrel monkeys. In the former of these, of which *Cebus apella*, figures 137 and 138, is a good example, the upper molars present a characteristic and in many respects a peculiar and distinctive pattern. The first molar is the largest of the series

* In *Cebus* the external root of the third and fourth premolars is either deeply grooved or completely divided at the end. This is likewise true of *Mycetes*, as well as of many species of Old World apes. An example of the fusion of the external roots is seen in the last molar of many species of apes where it is strongly reduced, as in *Cebus*, *Chrysothrix*, and others.

and the last is the smallest, being considerably reduced. In the crowns of the first and second, the trigonal ridges are distinct, and there is a prominent intermediate cusp present. The postero-internal cusp is well developed and has a position much more internal to the antero-internal than is generally the case in molars of the higher Primates. Because of its position this cusp is more widely separated than usual from, and does not develop a close connection with, the original trigon. There is a strong cingulum continued forward around the inner face of the crown, from which a small cingular cuspule is formed internal to the main antero-internal cusp. This is most dis-



FIGURES 139, 140.—Upper and lower teeth of *Chrysothrix sciurea;* crown views; twice natural size.

tinct in the second molar, although a considerable rudiment of it is seen in the first. In the squirrel monkey, *Chrysothrix sciurea*, figures 139, 140, and 141, the superior molars exhibit practically the same structure as those of *Cebus*, the only important difference between the two being that the posterior intermediate cusp is not distinct in *Chrysothrix*. The cingulum is continued around the inner face of the crown in both the first and second molars in the same way as it is in *Cebus;* but its development is greater in the first molar than in the second, whereas in *Cebus* the cingulum and the anterior cingular cusp are stronger in the second than in the first.

This peculiarity in the structure of the molars is not found in any other South American ape, nor, as far as I am aware, in any other living species of Primate in any part of the world. It is highly significant, therefore, that so unusual a modification and one so entirely unique among the Primates should be

met with in its incipient stages in the typical North American Eocene group Omomyinæ. As we have just seen, this character is found in the upper molars of all the species, and may be said to be especially characteristic of them. We know, moreover, that they are Primates; that the dental formula for the lower jaw and presumably for the upper is the same as in the Cebidæ; that the number, structure, and relations of all the teeth of certain species, at least, so completely fulfil the requirements and conditions which one would naturally seek in an ancestor of these living Cebidæ, as to make it scarcely possible to believe that such striking resemblances can be altogether accidental. In fact, this is the only group of Primates that has ever been found, among either living or extinct forms outside of South America, which exhibits any approximation to any of the Cebidæ, and until some tangible evidence to the

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FIGURE 141.—Lower jaw of *Chrysothrix sciurea*; side view; twice natural size.

contrary is forthcoming we are compelled to regard these extinct North American types as the source from which the ape fauna of the Neotropical realm had its origin.

It has been assumed by some who have sought to solve the problem of the origin of the Cebidæ, that they were derived from Africa, and making their way thence across an Antarctic land connection, thus reached South America. This view is based upon the presence in the Patagonian Miocene of the remains of numerous Marsupials closely allied to those now living in Australia, which argues strongly for a land connection with that continent during the Tertiary. From resemblances among certain living species from South America to those of Africa, as well as among some of the extinct forms, it is further assumed that this land bridge extended to Africa, and that there was an interchange of species between the two Hemispheres. While this may perhaps satisfactorily account for the presence of those African types in South America, it does not

apply to its simian population. The insuperable objection to an African origin for the Cebidæ is found in the complete absence of any group of Primates, either fossil or recent, in the tropics or any part of the Eastern Hemisphere, which exhibits any near affinities with the New World apes. Africa is to-day the congenial home of a large and varied lemuroid and simian population in which species of the highest and lowest degree exist side by side. Something is known, moreover, of the ancient representatives of this Primate fauna from the Tertiaries of Europe and Asia, but whether we consider the living or extinct forms, not a single species has yet been brought to light among them which does not proclaim its distinctive relationship and bear the unmistakable stamp of its affinities with the Primates of the Old World. Among the monkeys and apes, this is so positive that no one has ever ventured to assert the contrary.

In like manner, the fossil monkeys of South America exhibit the closest relations to those species now living there. Ameghino has found the remains of apes in the Santa Cruz Miocene of Patagonia, which are closely allied to, and hardly distinguishable from, the living *Cebus* of the Amazonian tropics. They exhibit no traces of relationship with any species inhabiting Africa. Any direct connection between the Cercopithecidæ and the Cebidæ may be dismissed, therefore, as utterly untenable and unsupported by a single fragment or vestige of evidence. Neither can it be logically argued that the Cebidæ, originating in Africa, migrated thence in a body to the New World. No assignable reason can be given why all the genera, species, and individuals of so large and varied an assemblage as the New World apes must have been, even prior to the Miocene, should have suddenly quitted the home of their birth, without leaving behind a single representative or trace which would furnish a clue to their former presence in a region now so well fitted, apparently, for ape existence. Any such vestige, however, is singularly absent, and from whatever point of view we choose to regard it, such a hypothesis appears simply impossible.

In connection with the evidence which I have already brought forward in favor of the North American origin of the Edentata, * a similar origin for the South American Primates, which is the only alternative hypothesis conceivable, is placed upon an extremely probable, if not absolutely secure, foundation, and is entitled to infinitely greater consideration than any purely conjectural origin of these forms, wholly without evidence in its support. I have formerly suggested that the so-called Litopterna were direct derivatives of *Meniscotherium* of our Wasatch

* The Ganodonta and their Relationship to the Edentata, Bull. Amer. Mus. Nat. Hist., vol. ix, pp. 59–110, 1897.

beds, and I now further venture to believe that all the South American Ungulates, including the Toxodonts, Typotheres, Astrapotheres, etc., are but modified descendants of our North American Condylarths, and were derived from the same region as the Edentates and Primates.

Subfamily Anaptomorphinæ.

As already indicated, the genera of this subfamily agree in having only eight teeth in the lower jaw. It is in all probability not a natural assemblage, since it is tolerably clear that the missing teeth are not the same in the various genera. Until this is more fully determined by better specimens, the present classification must be regarded as by no means final. The genera composing this group can be distinguished by the following characters:

Lower molars having four cusps on trigon, all distinct; heel of last molar with four cusps; first and second molars not especially wider behind than in front; last molar largest of the series; fourth lower premolar with moderately strong internal cusp and rudimental heel; third premolar with very small rudiment of internal cusp; canine larger than second premolar or incisor; only one pair of incisors in lower jaw (?); superior molars tritubercular, with more or less rectangular outline; intermediate cusps small, but distinct; postero-internal cusp well developed on crown of first and second molars, but not distinct on third.

Washakius.

Lower molars having only two cusps on trigon; last molar unknown in type; first and second molars widening rapidly behind; third and fourth lower premolars without internal cusps; canine larger than incisors; second premolar absent in type; two pairs of incisors in lower jaw; upper teeth unknown in type.

Anaptomorphus.

Lower molars having only two cusps on trigon, a vestigial anterior cusp on first; heel of last molar with three cusps; first and second molars wider behind than in front; last molar not reduced; fourth lower premolar with well-developed internal cusp; second tooth of the series vestigial and implanted external to the tooth line; superior molars quadritubercular.

Necrolemur.

Washakius insignis Leidy.

Washakius insignis Leidy, Contr. Ext. Fauna West. Terr., 1873, p. 123.

Leidy's type of this genus and species consists of a fragment of a lower jaw carrying the second and third molars so much worn as not to display the arrangement of the cusps. Up to the present, this specimen has remained the sole example of the species, which on account of its imperfect representation

has had no very definite standing. Its relationship to the Primates, even, has been called in question, and it has been thought by some to belong to the Rodentia. There are, however, about ten individuals represented in the Marsh collection, which I do not hesitate to refer to Leidy's genus and species. The most conclusive point in this identification is found in the extra cusp on the inner posterior surface of the trigon of the lower molars, the remains of which can be still plainly seen in the much-worn molars of Leidy's type. In one specimen in the Marsh collection, there is in association with the lower teeth a fragment of an upper jaw containing two molars, so that the structure of the teeth can be made out with a reasonable degree of accuracy.

The complete dental formula of the lower jaw is not known with absolute certainty, but in one specimen the front of the jaw is sufficiently preserved to render it highly probable that there was but a single pair of incisors. At all events, if the

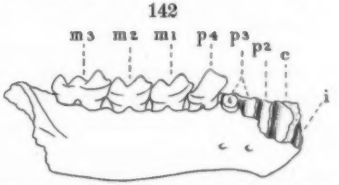

FIGURE 142.—Right lower jaw of *Washakius insignis* Leidy; side view; two and one-half times natural size; drawn from two specimens.

middle incisors were present they must have been exceedingly small. A good idea of the relations of the lower teeth can be had from the accompanying illustration, figure 142, which was drawn from two specimens. The outer side of the front of the jaw is injured so that the lower part only of the alveolus for the incisor is shown; this is seen to be smaller than that for the canine. Following this without diastema is a small alveolus for the second premolar, after which come the double-rooted third and fourth premolars. The crown of the second, figure 143, has a simple pointed summit, to which is added a small anterior basal, and a stronger internal cusp. That of the second has a similar structure but the internal cusp is better developed. In both the third and fourth premolars, the internal cusp is placed rather low upon the crown. The heel is rudimental.

The molars are peculiar in the composition of their crowns, by reason of the possession of an extra cusp situated internal and a little posterior to the main antero-internal cusp. The trigon thus has four cusps, a condition unknown in any other species of Primate. The remaining cusps of the trigon are

normal in their relations to the crown, the anterior one being distinct in all the molars. The heel of the first and second molars has the usual two cusps and is but little wider than the anterior portion or trigon. In the last molar, however, the heel has four cusps, which is again a unique character among

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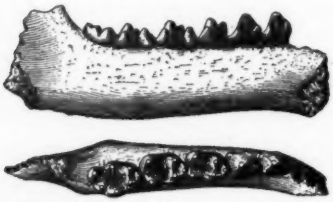


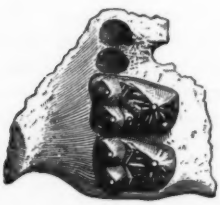
144

FIGURE 143.—Left lower jaw of *Washakius insignis* Leidy; inside and crown views; two and one-half times natural size; drawn from two specimens.

FIGURE 144.—Last left lower molar of *Washakius insignis* Leidy; crown view; five times natural size.

the Primates. An outline view of the grinding surface of the crown of the last lower molar of the left side, enlarged five times, is given in figure 144, which represents accurately the arrangement of the cusps. The enamel of the crowns of all

145



146

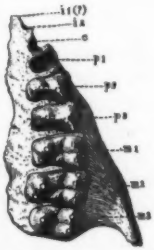


FIGURE 145.—Last two superior molars of the right side of *Washakius insignis* Leidy; crown view; four times natural size.

The postero-internal cusp of the second molar is not represented strong enough in the drawing.

FIGURE 146.—Left superior maxillary of *Washakius insignis* Leidy; crown view; two and one-half times natural size.

the lower teeth is strongly wrinkled, that occupying the valley of the heel especially so.

The fragment of upper jaw associated with the lower teeth, figure 145, contains the second and third molars. The second molar is larger than the third, although the disparity in size is not so great as in *Omomys* or *Hemiacodon*. The crowns are

tritubercular, with only a moderate development of the postero-internal cusp, and the cingulum is not continued forward around the internal face of the crown and does not develop the internal cingular cuspule seen in *Omomys* and *Hemiacodon*. The outer cusps are slightly flattened externally, and the intermediates are moderately developed. The enamel is much wrinkled, particularly that upon the inner portion of the crown. A second specimen, representing upper teeth, consists of a large part of the superior maxilla containing all the molars and the third and fourth premolars, figure 146. It also exhibits the alveoli of the second premolar, canine, and probably two incisors; that of the first incisor is, however, very indistinct, and one can not be sure that it was actually present.* In this specimen the second molar is larger than either the first or third, which are subequal. The postero-internal cusp is more distinct in the first molar than in the second or third. The premolars display single external and internal cusps, with a strong postero-internal cingulum tending to the formation of an additional cusp. The canine, as indicated by the size of the alveolus, is larger than the outer incisor or second premolar, and, as in the lower jaw, the teeth were implanted in a continuous row. The infraorbital foramen is single and issues above the anterior border of the third premolar in the same relative position as in *Hemiacodon*. The malar did not reach the lachrymal, thus leaving the maxillary a large share in the anterior boundary of the orbit, which was enlarged.

From these many resemblances to the Primates, there can not apparently be any question of the affinities of the genus, notwithstanding the peculiarities of the structure of the lower molars. It seems to have left no modified descendants, however, in the existing fauna.

Anaptomorphus æmulus Cope.

Anaptomorphus æmulus Cope, Proc. Amer. Philos. Soc., October, 1872 p. 554.

This genus and species were proposed by Cope upon the greater portion of a left mandibular ramus now preserved in the American Museum collection, which, as far as I am aware, is the only specimen of this species known. The jaw carries the first and second molars and the fourth premolar, together with the alveoli for all the remaining teeth, eight in all. The formula has been generally considered to be two incisors, a

* That which leads me to suspect the presence of two incisors in the upper series is the sharp inward curvature of the lower jaw near the symphysis, giving a greater transverse width in this region of the mouth. There would thus be a considerable gap left between the outer incisors and the median line. I think there can be little doubt that this space was occupied by a central pair of incisors.

canine, two premolars, and three molars, principally for the reason that the alveolus for the third tooth is enlarged after the manner of a canine, while the two in advance of it are small and hence have been thought to represent incisors. This determination is very probably correct, but it can not be accepted as final until the upper teeth are fully known. The extreme reduction in the number of premolars is a condition more advanced than that found in any other species of Primate, either living or extinct, in the Western Hemisphere; and that it should have taken place as early as the Eocene is indeed remarkable. In agreement with this reduction, it may be noted, however, that the structure of the lower molars is further advanced than that of any of its contemporaries in the Bridger. This is seen in the loss of the anterior cusp of the trigon from all the molars, and their consequent reduction to the four-cusped stage. I have already called attention to certain resemblances in the structure of the molars between *Anaptomorphus* and *Euryacodon*, but the former exhibits a greater advance in the modification of these teeth.

A second species, *A. homunculus*, was described by Cope from the now famous cranium found by me in the Basin of the Big Horn, in 1881. This cranium, together with a second specimen (No. 41 of the American Museum collection) which I also discovered in 1891, in the same region, has recently been refigured by Osborn.* These drawings are beautifully executed, but it is to be regretted that the skull is represented as complete in front, which is by no means the case. Osborn's figure gives the impression that the face is as much shortened and as reduced as in the highest type of living ape. Cope's original figure, in his Tertiary Vertebrata, is far more accurate in that it represents the entire anterior portion of the skull as missing. After a most careful study of the remains of this species in the American Museum collection, I find myself unable to agree with Cope in regard to the dentition of the cranium in question, or with Osborn concerning the dentition of the additional specimens. Cope determined the premolar dentition of the upper jaw to be two, and Osborn gives the number of lower premolars as three. The facts may be briefly stated as follows: In the cranium, there is evidence of the presence of seven teeth; of these, three are undoubtedly molars, and the remainder incisors, canine, and premolars; the most anterior tooth indicated is represented by an alveolus; the next is a pointed single-rooted tooth separated by a short diastema from those behind; the two following teeth are undoubtedly premolars, with single external and internal cusps.

* American Eocene Primates, Bull. Amer. Mus. Nat. Hist., 1902, p. 200.

The element of uncertainty comes in the determination of the nature of the first two teeth, and I can find no proof that the single pointed tooth is the canine, as held by Cope and Osborn. There is certainly no indication of the maxillo-premaxillary suture to be found, and the tooth in question may quite as well be a premolar as a canine. In fact, in the fragmentary maxilla of the other specimen (No. 41) there is evidence of a tooth with more than a single root in advance of the two premolars, and if the two specimens belong to the same species, which is more than likely, there were certainly three premolars in the upper jaw. In like manner I am unable to discover any conclusive evidence in favor of Osborn's statement that there are three premolars in the lower jaw, together with a canine and two incisors. I am strongly inclined to believe that there were three premolars in the lower jaw, however, and that Osborn's determination is correct; but at the same time the specimens are not sufficiently perfect to furnish conclusive proof of the fact. Nor can it be demonstrated at the present time that the Big Horn and the Bridger species belong to the same genus. Upon general considerations, I think it most unlikely. I believe, moreover, that the Big Horn species is a type with three premolars above and below, and that it is generically distinct from the Bridger *Anaptomorphus*. I have refrained from proposing a new genus for this species, preferring to let the matter rest until the dentition of both the Big Horn and the Bridger forms is more fully known.

In the matter of the restoration of the skull, I can find no warrant for the extremely abbreviated face which Osborn gives in his drawing. The contour of the muzzle was undoubtedly much more like that of *Tarsius*, with which the cranial anatomy so closely agrees. Apparently very little consideration has been given to these resemblances between *Tarsius* and the Big Horn fossil, which Cope pointed out. It will perhaps be well to recall them here, with some emendations and additions. They are as follows: (1) The species are of about the same size, both being small; (2) the brain development is relatively large; (3) the brain projects well backward beyond the foramen magnum, so as to overhang the occiput; (4) there is no sagittal crest; (5) the face is considerably shortened, and the orbits are large; (6) the canal for the internal carotid pierces the petro-tympanic; (7) the dentition is very probably the same, with the exception of the loss of one pair of incisors in the lower jaw in *Tarsius;* (8) the structure of the molars and premolars is very similar; (9) the bullæ are much inflated, and the external wings of the pterygoids extend backward, so as partially to enclose the bullæ externally; (10) the lachrymal extends out upon the face, and the opening of the lachrymal

canal is external to the orbit; (11) although not positively known, the relations of the lachrymal and malar are the same.

There are some differences to be noted, but they relate entirely to the assumption of modernized features on the part of *Tarsius*. Upon the whole, the resemblances are so striking and strongly marked that apparently there can not be the slightest question, not only of the close relationship between the two forms, but of the further important fact of their common origin. I have already suggested that the place of this origin was within an ancient circumpolar land.

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FIGURE 147.—Right lower jaw of *Necrolemur Edwardsi* Filhol; enlarged several times. (After Filhol.)

FIGURE 148.—Three lower molars of *Necrolemur Edwardsi* Filhol; crown view; enlarged. (After Filhol.)

Necrolemur may or may not belong in this series. If it does, it is by no means as closely allied to *Tarsius* as the American species. It has been suggested by Leche that it is related to the Indrisine lemurs, and there is indeed much in favor of such a view. If one compares the lower jaw of *Necrolemur Edwardsi*, figure 147, with that of *Propithecus diadema*, the resemblance in general form is at once apparent. The loss of the vestigial second tooth in *Necrolemur* would give the formula of the Indrisinæ, which is seven teeth in the lower jaw. *Necrolemur* differs from *Tarsius*, moreover, in the more advanced condition of the molars. In the lower jaw the anterior cusp of the trigon, figure 148, has completely disappeared, and in the upper jaw the molars are almost fully quadritubercular. *Microchærus* in all probability comes in the same group, and when more fully known should furnish a closer approximation to the Indrisinæ than *Necrolemur*, on account of the development of a mesostyle in the upper molars. A further character in which *Necrolemur* resembles the Indrisinæ is the lack of differentiation of the anterior teeth into incisors and canines, as well as their tendency to the procumbent position.

Paleontological Laboratory, Yale University Museum,
New Haven, Conn.

ART. XIX.—*Notes on a New Meteorite from Hendersonville, N. C., and on additional pieces of the Smithville, Tenn., Fall;* by L. C. GLENN.

LAST spring Dr. W. H. Jarman of Nashville added to the Jarman collection in geology here a stony meteorite which had been presented to him by Capt. C. F. Toms of Hendersonville, N. C. The writer immediately wrote to Capt. Toms asking for all the information he could give as to the time, place and circumstances of the fall or find. The following extract from his reply contains all the information obtainable on these points. "About the year 1876, when I was quite a boy, a meteor passed over this town from east to west. My father describes it as being as large as a 'wash pot' and it appeared to break into three pieces near the spot where this piece came from. It was very bright, lighting up the whole country and exploded with a great roar like a cannon. In 1901 Wm. Corn, a citizen living near the place, about three miles northwest of Hendersonville, brought this piece to us and we recognized what it was. He found it in the vicinity of what is known as the county home for the aged and infirm, probably on the land belonging to it."

The meteorite as received weighed 11 pounds and 6 ounces. The original weight, however, had been perhaps two pounds greater than this, as two pieces had been broken off before it reached the writer's hands. From one corner a large piece had been broken off, and from another a small flake had been removed. Concerning these pieces, Capt. Toms says, "The pieces broken off were used to make an assay (which has been lost) and therefore cannot be had."

The shape of the mass received was somewhat cubical, though one face of the quasi cube was considerably modified by an irregular portion projecting above it. The exact shape of this projecting portion cannot now be ascertained, as from it had been removed the larger of the two missing pieces above referred to. When resting on a face that may very conveniently be regarded as the base, it stands $6\frac{1}{8}$ inches high, is $5\frac{7}{8}$ inches wide and $5\frac{1}{2}$ inches thick. Its extreme diagonal length is 8 inches. The edges are all either gently or acutely rounded. A considerable portion of the surface is smooth and nearly flat, while the rest of the surface is covered with irregular, shallow pittings or undulations.

The underlying surface color is almost black, but it is generally obscured by rust-colored areas, due to weathering. On broken surfaces it is seen that weathering has produced a rusty-

colored layer a thirty-second to a sixteenth of an inch thick over most of the surface. While there are no cracks in the mass, yet the interior shows that weathering influences have made themselves felt to some extent at least through probably the entire mass. Freshly broken surfaces show a very dark gray mass with many minute rust-colored specks and numerous small masses of metallic luster and either a gray or a light pyritic yellow color.

A piece weighing one and a half pounds was removed and retained and the rest of the mass was given in exchange to the U. S. National Museum, and Professor G. P. Merrill will doubtless soon publish a description of the mineralogical and other characters of the stone. The fall is new and adds one more to the already considerable list of meteorites known from North Carolina.

Three pieces of meteoric iron from Smithville, Tenn., are mentioned by Huntington* in his description of the find. A fourth piece was sent, so the writer has been informed, to the U. S. National Museum. During the past year two additional pieces have come into the possession of the writer. They were found about forty years ago at Berry Cantrell's, one mile west of Smithville, Tenn. The larger mass weighed 3460 grams and was of compact rounded shape and evidently entire. The smaller weighed 478 grams and had had a portion removed by some one. The character of the masses was similar to that described by Huntington and, although the place where they were found was not just the same as that where the previously reported masses came from, they all belong undoubtedly to the same fall, which may have been scattered over a considerable area. Huntington's suggestion of collusion in these Smithville finds and his regarding them as being really part of the Cocke County iron, do not seem to the writer from his knowledge of the circumstances to be at all well taken. No object can be seen in any one going to the trouble of securing portions of a fall, carrying them several hundred miles across the mountains, secreting them forty or fifty years and then making presents of them to strangers! The only reasonable conclusion is that the Smithville finds fell near Smithville and not in a far distant corner of the state.

* Huntington, O. W., Amer. Acad. Arts and Sci. Proc., vol. xxix, pp. 251-260, 1894.

Vanderbilt University, Jan. 19, 1904.

ART. XX. — *Periodic Migrations between the Asiatic and the American Coasts of the Pacific Ocean;* by JAMES PERRIN SMITH.

THE fossil marine faunas of the western coast of the United States, of British Columbia, Alaska, Japan, and India are fairly well known, especially in the Mesozoic era. These faunas are now similar, now different in the various provinces, or in parts of them, presenting an apparently inextricable confusion not capable of any rational explanation. But this confusion is only apparent, for when studied in succession, a regular scheme can be traced in the relationships and diversities of this ancient region. And the changes that are noted point to changes in physical geography that would be insignificant in themselves, compared with continental uplifts and subsidences, though by no means insignificant in their effects. Also there is abundant independent physical evidence that these changes really took place, so they are in no sense merely hypothetical.

Briefly stated, the facts are these. There is at present a remarkable similarity in the living marine molluscs of the western coast of North America and of the eastern coast of Asia in approximately the same latitudes, and this similarity can be traced back with certainty until the Lower Trias, and probably even below that. But the resemblance is not continuous, there being periods in which the faunas were unlike, and these periods of interruption recur several times, although not regularly. It is clear that no migration is taking place between the opposite sides of the Pacific now, and equally clear that such migration did go on in comparatively recent geologic time, when a large part of the present species of marine invertebrates already existed. It remains to state the facts in succession, and then to show how the intermigration must have taken place, and the cause of the periodic interruptions, reasoning back always from modern conditions to those of the past.

Ancient Faunal Relations.

Paleozoic time.—We know little with certainty of the faunal geography of the Paleozoic of the western coast of America except that during the Carboniferous the connection seems rather to have been with northern Asia than with the interior of North America. The kinship of American and Asiatic forms can not be charged to universality of faunas or physical conditions, for we know that there was nearly as much provincial differentiation in the marine Carboniferous as there is now.

Lower Trias.—The writer* has already shown in several papers that the Lower Trias of California and the Great Basin shows an intimate relationship to that of Asia, and none with that of the Mediterranean region. Many genera are represented by closely allied species on both sides of the Pacific Ocean that are wholly unknown in Europe at that time; such are *Flemingites*, *Ophiceras*, *Proptychites*, *Lecanites*, *Aspidites*, *Clypites*, *Pseudosageceras*, *Ussuria*, and many others. Some of the species of these may even be identical, but even without this the association of the genera is such that a paleontologist from Asia would feel himself to be perfectly at home while collecting in eastern California or in Idaho. In some respects the relationship of the fauna of the western coast seems to be closer with that of northern Asia than with that of India; for instance, *Pseudosageceras* and *Ussuria*, which are not uncommon in the Meekoceras beds of the Inyo Range in California, and the Aspen Mountains of Idaho, have never been found anywhere else except at Ussuri Bay in eastern Siberia, from which place they were first described. These genera are probably not of American origin, and most of them are of unknown antecedents. But, fortunately, the geologic history of some of these forms is known. *Ophiceras*, *Xenaspis*, *Xenodiscus*, and *Hungarites*, which occur in the Trias of Asia and America, chiefly in the lower beds, have also been found in the Permian of southern Asia. To this region, then, we must look for the source of the Lower Triassic ammonites which appear as immigrants in the American waters, marking the first distinct Asiatic invasion.

After the deposition of the Meekoceras beds, a few species with Mediterranean affinities begin to make their appearance in western America. But it is noteworthy that, at this time, the Indian still appears to have been cut off from the Mediterranean region.* The geographic regions described by E. von Mojsisovics† for the Trias will hold good only for the Lower Trias, and probably not even for the whole of that period.

Middle Trias.—In the Middle Trias a certain kinship still persists between the marine faunas of western America and Asia, though this may be due as much to inheritance from similar ancestors, as to immigration. No species are any longer common to the two regions, and many genera, even, are different on opposite sides of the ocean. But at the same time a kinship between the American and the Mediterranean faunas begins to be noticeable, especially in the nodose ceratites and other members of the Ceratitidæ. It is possible that during

*Jour. Geol., vi, 776–786, 1898; Jour. Geol., ix, 512–521, 1901.

†Arktische Trias-Faunen, pp. 147–155, 1886, and Beitr. Kennt. obertriadischen Cephalopoden-Faunen des Himalaya, pp. 114–128, 1896.

the Middle Trias a connection was established between these regions through some other way than the Indian branch of the old central Mediterranean, or "Tethys," but we have no way of knowing this passage. It seems possible, however, that it may have been through the Boreal region. The writer* has already given a suggestion of the faunal change at the end of the Lower Trias, based on his own collections made in Nevada during the summer of 1902. No species are thought to have been absolutely identical with European forms, but many are so similar to species long known from the Alps that some sort of connection is beyond question.

Upper Trias, Subbullatus beds.—The writer† has brought out several years ago the relationship of the Trias of California to that of the Alps. Further study, in field and museum, has served only to strengthen this hypothesis, and recent work in India has given a means of comparison with that region, showing that the same thing is true there also.

The Karnic horizon, zone of *Tropites subbullatus*, contains many elements common to the Mediterranean region and western America, and many of these are also found in India. *Tropites subbullatus*, *T. torquillus*, *Paratropites Sellai*, *Entomoceras sandlingense*, *Sagenites Herbichi*, *Polycyclus Henseli*, and *Halobia superba* are common in both California and the Tyrolean Alps, and many other species are very closely related. Most of these are represented in India by forms that may be identical with them, although complete publication of recent geologic explorations in India must be awaited before a final decision can be made.

Now it is well known that the Tropitidæ appeared as immigrants in the Mediterranean and the western American regions in the Upper Trias, without local ancestors. They also appeared at the same time in India, but since we do not yet know the faunas of the upper part of the Middle Trias in that region, there is still a possibility that the Orient may have been the source of this part of the fauna, for it is highly probable that the Indian province was the connection between Europe and America. This Karnic fauna, however, is not yet known elsewhere in Asia, and the only proof we have of the migration is the occurrence of similar species in the widely separated regions. The path of this migration cannot be traced, for fossils of the zone of *Tropites subbullatus* are known in America only in California, not having been found at any other place in either North or South America.

Upper Trias, Noric horizon.—Fossils of the Noric horizon,

* Centralblatt für Mineral. Geol. und Pal., pp. 689–695, 1902.

† The Metamorphic Series of Shasta County, California, Jour. Geol., ii, 588-612, 1894.

zone of *Pseudomonotis ochotica*, are known in Alaska, British Columbia, California, Nevada, and as far south as the coast of Peru. *Pseudomonotis ochotica* is widely distributed in Siberia and Japan, and is probably identical with the American *Pseudomonotis subcircularis*. This group is distinctly Asiatic in origin, and never reached the Mediterranean waters. Its appearance in America marks another Asiatic immigration, but this time it came from the north. We see here a reversion to the conditions of the Lower Trias, but on the Asiatic side the immigrants do not seem to have reached any further than to Japan. The widespread occurrence of beds with *Pseudomonotis ochotica* around the northern shores of the Pacific and around the Arctic Ocean shows a transgression of the sea on what was formerly a continental border. These forms were endemic in the Boreal region, and made their way southward when the transgression of the sea opened the way, on both sides of the Pacific. Of course, this may not have had anything to do with climate, but at the close of the Karnic epoch the fauna of western America shows a sudden change of facies from the Indian-Mediterranean character to that of Siberia, which shows, at least a change in connections. A passage from the Arctic to the Pacific was reopened between Asia and America, and the Boreal, though not necessarily cold-water, type came through, making its way southward.

Deep water, cutting off Asia from America, would have separated the two Triassic regions just as effectively as cold water, but since there was free passage for the group of *Pseudomonotis ochotica* down both sides of the Pacific, it is strange that it did not reach Tropical India, and that the Tropical Indian forms ceased temporarily to come to America. If such changes had occurred in Tertiary time we would say without hesitation that the Boreal invasion marked an influx of cold water from the Arctic Ocean through the open passage between Asia and America.

The group of *Pseudomonotis ochotica* has also been cited by Suess* from New Caledonia, but this occurrence is doubtful, since Rothpletz† found only *Monatis salinaria*, a Mediterranean type, in that region. It may be, however, that in the Indian Ocean the Boreal and the Mediterranean facies were temporarily united, in which case the presence of *Pseudomonotis ochotica* would not necessarily be a proof of the southward extension of a lower temperature.

A modern instance of the same restricted dispersion is seen in the occurrence of *Purpura lapillus* in the North Pacific.

* La Face de la Terre, ii, 422.

† Perm-, Trias- und Jura-Formation auf Timor und Rotti im indischen Archipel, p. 90.

This species is abundant in the North Atlantic, and has made its way through the Boreal region into the Pacific. On the western coast of North America, where there are no sudden changes in the temperature of the sea water, this species has made its way as far south as Margarita Bay, in lat. 24° N., mean temperature 73° F. On the Asiatic side it has made its way through Bering Sea down the shores of Kamschatka with the cold water, but has been stopped by the sudden change of temperature at Hakodadi, lat. 41° N., Japan, mean temperature 52° F., where the warm Japan current meets the cold current from Bering Sea. That this is not an accident of distribution is shown by the fact that *Purpura lapillus* has, in the Atlantic, a similar distribution, and for the same reasons. On the African side it reaches lat. 32° N., mean temperature 66° F., and on the American side it is barred back by the sudden change of temperature at lat. 42° N., mean temperature 52° F.* There can be no doubt that the temperature, or rather evenness of change of temperature, controls the distribution of *Purpura lapillus* now, and it would seem only reasonable to suppose that similar conditions in the Trias caused the unequal distribution of *Pseudomonotis ochotica*.

Lias.—It is probable that during the Lias the southward migration of the Boreal type of animals was interrupted, for the *Arietites* group, which was characteristic of that epoch in Europe, is known in California and Nevada, as well as in Mexico and South America. It was, however, practically universal, having been found also in the Indian region, though not as yet from the Jurassic Arctic sea. In the Upper Lias the genus *Amaltheus* was widely distributed in Europe and in the Boreal region, but has not yet been found in North America. It is known from New Grenada, associated with a typical Mediterranean fauna. It seems probable that the Lias of California and Nevada is merely a northward extension of the South American type.

Middle Jura.—In California the Middle Jura, like the Lias, appears to have been of Mediterranean type, but in the Black Hills we have a southward extension of a fauna characteristic of northern Europe, and of the region around the northern Pacific Ocean. This boreal type is extensively developed in Alaska and in northern Siberia, and its appearance in the Black Hills marks the beginning of another incursion from the north.

Upper Jura.—The incursion of the Boreal fauna into America which began in the Middle Jura reached further southward and westward in the Mariposa epoch of the Upper Jura, down through California to San Luis Potosi in Mexico.

*A. H. Cooke, Cambridge Natural History, iii, p. 363, 1895.

This fauna is characterized by the genera *Cardioceras* and *Aucella*, which had their home in northern Europe and northern Siberia, and appeared in western Europe only sporadically as the result of incursions. Pompeckj* has shown in several papers that a Polar sea existed in the Middle and Upper Jura and Lower Cretaceous, from which incursions were made from time to time into the more southerly regions, when changes in physical geography made it possible. He has also shown that the *Aucella* fauna had its real home in that region, where it formed a truly genetic series, and that it appeared only sporadically in other regions, where the species speedily degenerated and the fauna becomes extinct unless replenished by another migration.

The suggestion of climatic influence on the dispersion of marine animals in the Upper Jurassic is very strong, for the *Aucella* did not make its way into the Indian Ocean, although the way was probably open. It went only where the conditions of its own proper habitat existed, if only temporarily. Even so conservative a naturalist as J. D. Dana† admits that in Jurassic time there was a cold current to the southeast along the western coast of North America, making possible the migration of *Aucella* from the Boreal into warm temperature or even subtropical waters.

Aucella did, however, make its way into northern India, probably from southern Russia, during a time of extension of the sea in that direction in the Kimmeridge and Tithonian epochs.‡

Lower Cretaceous.—After the Jurassic beds were laid down there was in California a break in sedimentation, and the uplift of the Sierra Nevada took place. But it was orogenic, and although widespread, it did not affect the geographic relations, for with the opening of the Cretaceous the same northern types were still there. *Aucella* was still the most characteristic genus, and along with it were many species of ammonites closely related to Russian species. *Aucella crassicollis* was even identical with a characteristic Russian form. These Knoxville species were probably in part immigrants from the Boreal region, although some of them may have been modified descendants from species that were endemic in the American

* Ueber Aucellen *etc.* N. J. für Min. Geol. und Pal. xiv, 343, 1901 and Jura Fossilien aus Alaska, Verh. k. o. Russ. Min. Gesell. (St. Petersburg), xxxviii, 376, 1901. The Jurassic Fauna of Cape Flora, Franz Josef Land; The Norwegian North Polar Expedition 1893-1896, Scientific Results, p. 141, 1898.

† Manual of Geology, p. 794, 1895.

‡ S. Nikitin, Bemerkungen über die Jura-Ablagerungen des Himalayas und Mittelasiens. Neues Jahrb. für Min., Geol. und Pal., ii, 124, 1889.

waters. Before the end of the Knoxville epoch, while the Boreal forms still persisted, *Lytoceras* and *Phylloceras*, genera that were never found in northern Europe and Asia, appeared in the Cretaceous beds of the western coast of America. These forms seem to have been endemic in the warm regions of southern Europe and Asia, and their appearance marks a resumption of interchange between India and America, around the shore-line formed by closing the gap between Asia and Alaska. In proof that the gap was really closed, it may be said that the flora of the Knoxville beds and of the equivalent Kootanie formation appears to indicate a warm temperate climate,* which would mean that the cold current from the Arctic Ocean had been cut off by a rise of the land.

During the Lower Cretaceous *Aucella* made its way into the Tropics, around the Pacific Ocean, so that its later occurrence gives no evidence of southward extension of Boreal climatic conditions.†

Upper Cretaceous.—With the opening of the Horsetown epoch all reminiscences of the Boreal fauna are gone, and the Tropical character of the inhabitants of the sea on the western coast of America is marked. A close affinity and even identity of species with the Indian fauna characterizes this epoch. And it is noteworthy that the Puget Sound Horsetown and Chico faunas are even more closely allied to those of India than are those of California. Migration appears to have been free between Asia and America, but the species did not all range so far south as California, thus indicating the direction from which they came. Of course, not all the marine forms on the west coast of North America came from Asia, but the Asiatic portion is the only one that we can trace to its source.

The following species that occur in the Horsetown and Lower Chico of western America are regarded by Kossmat‡ as identical with species in southern India:

Lytoceras Kayei Forbes.
L. —— *timotheanum* Mayor.
L. —— *cala* Forbes.
L. —— *indra* Forbes.
Hamites glaber Whiteaves.
Schloenbachia inflata Sowerby.
Acanthoceras Turneri White.
Pachydiscus otacodensis Stoliczka.
P. —— *arialurensis* Stoliczka.
Desmoceras diphylloides Forbes.

* T. W. Stanton, Jour. Geol., v, 599, 1897.

† Pompeckj, Ueber Aucellen und Aucellen-ähnliche Formen, Neues Jahrb. für Min. etc., xiv, 348, 1901.

‡ Beitr. Pal. und Geol. Oesterreich-Ungarns und des Orients, ix, Parts 3 and 4, 1895.

Desmoceras latidorsatum Michelin.
Puzosia planulata Sowerby.
Hauericeras Gardeni Bailey.
Phylloceras Whiteavesi Kossmat.
P. —— *Velledae* Michelin (cited as the probable equivalent of *P. ramosum* Meek).

Besides the above, F. M. Anderson* describes the following species from the lower Chico beds as identical with Indian forms: *Schloenbachia propinqua* Stoliczka, *S. blanfordiana* Stoliczka, *Desmoceras sugata* Forbes. Nearly all these species that are common to the western coast of America and India also occur in Japan, and many of them also in eastern Africa. They are, then, tropical or subtropical in habitat. Whether the appearance of the *Aucella* fauna of the Upper Jura and the Lower Cretaceous in the North Pacific meant cold water or not, the appearance of the Indian forms in the same region can only be interpreted to mean that a warm temperature prevailed there at that time, and that conditions were equable around the old shore line from India as far as California.

With the closing of the passage between Asia and America, the warm Japan current, which is now chilled by the cold southwesterly current from Bering Sea, would warm up the whole coast line and make the waters of western America warmer than they are now. We also have evidence that the temperature of the land in the northern hemisphere was warmer than at present, for Heer† has shown that the Cretaceous floras of Greenland, Spitzbergen and Alaska contained cycads and other forms indicating a mean temperature of about 70° F.

Upper Chico.—In the upper Chico horizon (Senonian), of California and Oregon the connection with India appears to cease, and a path of migration from the interior Cretaceous sea of America seems to have been opened.‡ Several species of pelecypods are identical with species from the upper Missouri province, and some of the ammonites are closely allied.

Eocene.—During the early Tertiary, or Tejon epoch, in California we have no evidence of any migration from Asia, but it is plain that a connection existed with the Eocene sea of the Atlantic region. *Venericardia planicosta*, which is abundant in the Claiborne beds of the states around the Gulf of Mexico, has been found at a number of places in Oregon and California, and it appears to be more common in southern California than anywhere else on the western coast. Other

* Cretaceous Deposits of the Pacific Coast, Proc. Calif. Acad. Sci., iii, Ser. Geol., vol. ii, No. 1, 1902.
† Flora Fossilis Arctica, vi and vii, 1882–83.
‡ F. M. Anderson, Cretaceous Deposits of the Pacific Coast, p. 59, 1902.

species of this fauna may be identical with Atlantic forms, at any rate some are closely related, and it is probable that the passage lay to the south of California.

Miocene.—In the middle Tertiary the passage to the Atlantic seems to have been closed, and there is no evidence that communication was resumed with Asia. The Miocene fauna of California seems to have been largely endemic, for no Atlantic species are found in it, and the only possible admixture consists of forms from the south, and of circumboreal species that made their way down from the north. But towards the end of Miocene time the land appears to have risen in the north, cutting off the Arctic Ocean from the Pacific, and allowing land plants to migrate from Asia to North America. Asa Gray* has shown that in the Miocene northeastern Asia and northwestern America were connected, that over those regions there existed a flora like that of warm temperate latitudes at the present time, and that this connection persisted almost to the beginning of the Glacial epoch.

We have no evidence that a migration of marine invertebrates from Asia began as early as the upper Miocene, but they would naturally be slower in their movements than land plants, and consequently would lag behind them. The Tertiary uplift of land in the northern hemisphere may be correlated with the widespread orogenic uplift of the Coast Ranges on the Pacific side of North America, which in California and Oregon is known to have come at the end of the Miocene, and before the Pliocene beds were laid down.

Pliocene.—There is good geologic evidence that the land-bridge between Asia and America still existed in the Pliocene, for there seems to have been a constant interchange of vertebrates in that quarter,† in the Miocene, Pliocene, and early Pleistocene. Also students of other groups find it necessary to postulate such a connection to explain the migration of animals. A. E. Ortmann‡ says that the identity of some of the fresh-water crustaceans in Siberia and Alaska proves a recent connection of those parts, and that this union of the continents began in the middle of the Cretaceous and lasted into the lower Pleistocene. G. M. Dawson§ is of the opinion that in the Pliocene the Pacific coast of North America stood about 900 feet higher than now, which would be ample to connect the two continents, and cut off the cold water from the North Pacific. And we still have evidence of this former elevation of the Alaskan region, for in the Aleutian Islands,

* Amer. Jour. Sci. (3), cxvi, 195, 1878.
† H. F. Osborn, Science, xi, 571, 1900.
‡ Proc. Amer. Phil. Soc., xli, 291, 299 and 316, 1902.
§ Quoted in Dana's Manual of Geology, 949, 1895.

commonly regarded as a chain of new volcanoes, granite appears in several places.*

At this time the marine faunas of Japan and the western coast of America begin to be remarkably similar, with many species identical, which can only mean that intermigration had set up along the shore line. And the identical species are not merely circumboreal, for many of them have never been found in the Boreal region. A list of these, and their geologic range, will be found on the table on page 229.

The rise of the land in the northern hemisphere, as shown by the distribution of land and fresh-water animals, would cut off the southward cold current from the Arctic Sea, and prevent the chilling of the Japan current south of Bering Sea. The Japan current would then warm the shores of Alaska, and produce a mild temperature along the old shore line from Japan to California. That it did so is shown by the similarity of the Pliocene faunas of the two now separated regions. At first there was naturally a mixture of Boreal and Japanese forms, for D. Brauns† has shown that the Pliocene of Japan is related to the "Crag" of England; and the upper Pliocene of California appears to indicate a temperature of the sea-water somewhat lower than at present. At any rate, it is clear that the climate around the North Pacific in Pliocene time was merely temperate; this is shown by the fact that while we have an immigration of Japanese species, no Indian forms came with them, as they did in the Upper Cretaceous, when the climate appears to have been subtropical.

Pleistocene and Recent Faunal Relations.

San Pedro epoch.—With the beginning of the Pleistocene the same conditions existed as in the upper Pliocene. Japanese species still abound in the marine fauna, and the character is still somewhat boreal,‡ which may be due to a survival of forms that came in during the colder Pliocene epoch. The land connection with Asia still existed, and free exchange of land animals between Asia and America still went on.

As the waters of the Californian coast gradually became warmer, Mexican species began to creep northward, and in the upper San Pedro fauna we find a number of species that now live only in the Tropics, and have become extinct on the Californian coast.§ This does not mean that connection with Japan

* J. E. Spurr, U. S. Geol. Survey, 20th Ann. Rept., Part vii, 234, 1900.

† Geology of the Environs of Tokio, Mem. Science Dept., Univ. of Tokio, No. 4, pp. 1–82, 1881.

‡ Delos and Ralph Arnold, The Marine Pliocene and Pleistocene Stratigraphy of the coast of Southern California, Jour. Geol., vol. x, No. 2, pp. 117–138 (1902).

§ Ralph Arnold, Mem. Calif. Acad. Science, iii, 29 et seq., 1903.

was cut off, but that the continuation of the conditions that allowed Japanese species to migrate to California finally allowed marine animals to make their way up the coast also.

Glacialists postulate an elevation of the land in the northern hemisphere, in the period preceding and during the Glacial epoch; this undoubtedly cut off the migration of land animals and plants between Asia and America. When this affected intercommunication along the shore-line we do not know, but after the close of the San Pedro epoch the Asiatic immigration ceased, and also the subtropical elements of the marine fauna of California became extinct. With the subsidence following the Glacial epoch conditions returned to the normal, and intermigration with Japan was not resumed. It was too cold for the perpetuation of the warm-water species from the south, though not too cold for the Japanese species to live on in the Californian waters. But the Asiatic colonists in America were not replenished by immigration from the mother country, and those that are found in the Californian province are merely survivors.

Relations of the living faunas of the west coast to that of Japan.—The table on page 229 shows the living species that are common to the western coast of North America and the Japanese province. The number of species is very large, especially when we consider the fact that they are in different zoölogic regions, and separated by more than five thousand miles. Migration of shore forms can not possibly be going on now, for while the distance is no bar to them, the deep water at the end of the Aleutian chain of islands would effectually check all passage in either direction. And the sudden changes in temperature through which marine animals would have to pass are an equally effectual barrier. We have seen already how even a circumboreal species, as *Purpura lapillus*, is checked in its southward passage where the cold current from Bering Sea meets the warm Japan current. Such changes are even more impassable to warm-water species.

In the present similarity of the marine faunas of Japan and the western coast of America we have an example of provinces that were recently connected, but which are now separated by deep water and by differences of temperature in between, while the conditions still remain similar in the two provinces. This separation, however, has existed long enough for some of the species to have become differentiated by evolution, for some to have become extinct in one province while still living in the other, and for the total faunas to have become much changed by immigration from other regions.

At first sight it would seem that the intermigration of the marine faunas has been more recent than the exchange of the

land animals and plants between Asia and America. And indeed this may be so, for a subsidence that would cut off effectually all land organisms might not interfere with the migration of marine animals living at moderate depths. For instance, *Haliotis*, a distinctly Asiatic type, is not known on the west coast of America before the upper San Pedro epoch, and has now made its way southward below California. On the other hand, we must remember the conservative character of marine faunas. Where in the land Pleistocene faunas most of the species have been replaced by others, of the marine Pleistocene animals only a very small percentage has become extinct. We must also note that, of the species now common to the two sides, a large proportion is known to have existed in Tertiary time, and probably nearly all in Pleistocene. In the time that has elapsed since the two provinces were separated, *Lucina acutilineata*, which abounded during the Pliocene in both Japan and California and is still living in Puget Sound, has become extinct in Japan. *Mya arenaria*, also abundant in the Pliocene in both provinces, has become extinct in California, while it still persists in Japan. It has, however been introduced artificially late in the nineteenth century and now abounds in most of the bays on the west coast. On the Alaskan coast *Mya arenaria* did not become extinct, though it did not make its way down to California. It is also probable that *Pecten caurinus* on the west coast and *P. jessoensis* in Japan have become differentiated from their common ancestors.

All this points to a rather ancient separation, not later than the upper San Pedro epoch, at which time the warm-water fauna came up from the south, and never reached Japan.

Summary.

Present physiography.—The living faunas of the Japanese province and of the western coast of North America are rather closely allied, with a large number of species in common, and they live under approximately the same conditions, although they are in widely separated regions. Between them lies a stretch of shore-line running up to lat. 60° N., around the southern shores of Alaska and the Aleutian Islands, but interrupted by the deep channel east of Kamchatka. Also there is a great difference of temperature between them. The warm Japan current, with an average maximum temperature of 86° F., flows past Japan, swings to the northeast, south of the Aleutian chain towards America, and parts off Puget Sound, one branch flowing northwestward along the Alaskan coast, and the main branch southeastward down towards California.

TABLE SHOWING LIVING SPECIES COMMON TO THE WEST COAST AND JAPAN.

	Japanese Province.			West American Province.		
	Pliocene.	Pleistocene.	Living.	Pliocene.	Pleistocene.	Living.
Barbatia gradata Sowerby			×			×
Cardium blandum Gould			×	×	×	×
Cardium corbis Martyn	×		×		×	×
Chlamydochiton annulatus Pallas			×			×
Crepidula grandis Midd.			×	×		
Cryptochiton Stelleri Midd.			×			×
Diplodonta orbella Gould	×		×		×	×
Dentalium hexagonum Sowerby	×		×	×	×	×
Haliotis Kamtschatkana Jonas	×		×			×
Laqueus californicus Koch			×	×	×	×
Lascæa rubra Montagu	×		×		×	×
Leptothyra Carpenteri Pillsbry			×			×
Lima orientalis Adams	×		×			×
Littorina sitkana Philippi			×			×
Lucina borealis Linné	×			×	×	×
Macoma edulis Nuttall						
Macoma inquinata Gould			×			×
Macoma nasuta Conrad	×		×	×	×	×
Macoma secta Conrad			×	×	×	×
Modiola flabellata Gould	×			×		
Macron Kelletii A. Adams			×			×
Mopalia muscosa Gould			×			×
Murex foliatus Gmelin			×		×	×
Mya arenaria Linné	×		×	×		
Mytilus edalis Linné	×		×		×	×
Nuonla Cobbeldiae Sowerby	×		×			
Natica clausa Broderip			×		×	
Panopœa generosa Gould	×		×	×	×	×
Pecten caurinus Gould	?		?	×	×	×
Pecten jessoensis Stimson	×		×			
Pecten hericeus Gould			×	×	×	×
Pecten islandicus Müller			×	×	×	×
Placuanomia macroschisma Deshayes			×	×	×	×
Purpura crispata Chemnitz			×	×	×	×
Purpura lapillus Linné	×		×	×		×
Sanguinolaria Nuttalli Conrad			×			×
Saxidomus Nuttalli Conrad			?	×	×	×
Siphonalia Kelleti Hinds			×		×	×
Siliqua patula Dixon			×			×
Solen sicarius Gould			×	×	×	×
Tapes staminea Conrad			×	×	×	×
Tellina bodegensis Hinds			×	×	×	×
Terebratulina caput-serpentis Linné	×		×			×
Tresus Nuttalli Conrad	×		×	×	×	×
Tritonium oregonense Redfield			×		×	×
Trophon orpheus Gould			×	×	×	×
Velutina laevigata Pennant			×		×	×
Venus Kennerlyi Carpenter			×			×

But in lat. 42° N., off Hakodadi, Japan, it is met by the cold current from Bering Sea along the coast of Kamchatka, and from there on the current is merely temperate, being reduced

to about 66° F. It tempers the Alaskan waters, but makes the waters along the shores of California colder than they should be, as compared with similar latitudes elsewhere. These currents have been fully described by Professor George Davidson,* who has made many hydrographic investigations in that region; and by Dr. W. H. Dall,† who verified much of the work of Professor Davidson, but showed that there was no northward branch of the Japan current extending up into Bering Sea.

At present the migration of shallow water species is stopped by the depth of the channel at the end of the Aleutian chain, and also by the cold water that extends southwestward from Bering Sea. But a rise of 200 meters would close Bering Strait, and about one-half of Bering Sea, giving a shore-line coinciding approximately with a great circle. It would then leave the Aleutian chain as a long narrow peninsula reaching out from Alaska towards Siberia, separated from Kamchatka by a rather narrow but deep channel; while the mainland of Alaska and Siberia would be united by a broad land-bridge. This change in the height of the land would cut off all influx of cold water from the Arctic Sea, and the Japan current, not being chilled by cold water from Bering Sea, would still be warm along the Aleutian Islands and the Alaskan coast, and no doubt the tempering effect would be felt even as far south as California. A rise of 2,000 meters would not connect the Aleutian chain with Kamchatka, but at least would give a stretch of shoal water along which migration would be easy for shore forms. In any case there would be a shore line with temperate or warm water all the way from Japan to California.

While it is not likely that the land in the northern part of the Pacific has, in recent geologic times, stood 2,000 meters higher than now, it has certainly stood several hundred feet higher, and whether much or little, we know from the migrations of land plants and animals between Asia and America that there has been a land-bridge. Now in any case, whether in the present or in the past, similar contemporaneous faunas mean similar conditions, and identical species mean immigration from one region to the other, or from a third region to both. In the case of Japan and the west coast of America the only outside region that can have furnished elements to both is the Boreal region, and circumboreal species in both provinces are well known. But a large majority of the species now common to both provinces are not circumboreal. Thus intermigration is the only satisfactory explanation of the pre-

* Report Supt. U. S. Geodetic Survey, 1867, Appendix No. 18, p. 202,1869.

† Rept. Supt. U. S. Coast and Geod. Survey for 1880, Appendix No. 16, p. 322.

sent distribution of most of the species that are common to Japan and California.

Unlike species living contemporaneously in similar conditions can only mean separation by physical barriers; these to the marine shore-animals are: a land-mass; deep water; or great difference of temperature in between. The two latter are the only barriers that can ever have been interposed between Japan and the west coast of America, and a rise of 200 meters would remove both.

The hypothesis of former migration around the Alaskan-Aleutian shore-line explains satisfactorily the close relationship between the living marine animals of Japan and California, while the present interruption and the length of time during which it has persisted explain the unlikeness of the greater part of the two faunas. A periodic recurrence of this interruption accounts for the periodically recurring unlikeness of faunas of these two provinces in the past, and also for the fact that the successive faunas of California do not form a genetic series, but rather one showing periodically diverse origin and characters. With this in mind we can find out where the successive migrations came from, and why the present fauna shows such a commingling of forms derived partly from Asia and partly from the more southerly regions of America.

Past physiography.—The old idea of uniformity of climate all over the earth before the Tertiary period still remains as an undercurrent in the minds of geologists, and stands in the way of any theory that accepts the influence of differences of temperature in causing faunal differences in the past. Stanton* denies that the change of character of the Cretaceous fauna of the west coast at the end of the Knoxville epoch, from the Boreal to the Indian type, can be attributed to change in climate. Others have criticized Neumayr's† theory of climatic zones in Jurassic and Cretaceous times, and there can be no doubt that Neumayr carried his theories entirely too far, reconstructing ancient physical geography on very little evidence. But the fact that Neumayr was mistaken in many things is no argument that the principle was wrong. No doubt geographic connections and presence or absence of opportunities for free intercommunication were of just as great importance as differences of temperature in governing the distribution of faunas in the past, as well as now. But it will not do to leave climate entirely out of the reckoning.

The assumption of a uniform temperature over the earth before the Tertiary period rests on an insecure basis. If any

* Jour. Geol., v, 598, 1897.

† Klimatische-Zonen während der Jura- und Kreidezeit. Denkschr. k. Akad. Wiss. Wien, xlvii, 1883.

former climate was uniform, it must have been warm, and the temperature must have been warmer the further we go back in geologic history. And yet we have evidence that the temperature was not uniform even in the Paleozoic. It is well known that over parts of India, Australia and South Africa there is good evidence that there was a Permian glacial epoch, while we know from abundant contemporary floras in other parts of the earth that this glaciation was not universal. In South America in the same latitudes as the glaciated region of the Orient there does not appear to have been a cold period. In this, then, we have proof that there was great diversity of climate even in the Paleozoic era.

Now it would be absurd to account for the difference between the cold-water faunas of California in the Pliocene and lower San Pedro formations and the warm-water fauna of the upper San Pedro, and the contrast between the latter and the present cooler water fauna of the California coast, on any other hypothesis than differences of temperature. For all this is based on species that are still living, where we know the exact conditions of geographic connection and temperature under which they live, and by which their distribution is governed. These differences of temperature are slight, and the changes in physical geography that caused them are insignificant, though far-reaching in their effects. All this, of course, applies only to the shore lines affected by the marine currents, and does not necessarily have anything to do with continental climates.

It would seem equally rational to explain similar distribution in the past by the same hypothesis. The faunal relations between western America and eastern Asia from the Trias to the present were the same, Asiatic facies alternating with periodically recurring invasions of the Boreal type. If differences of temperature can account for the connections and separations of the living faunas, they must be taken into account in explaining similar connections and separations in Tertiary, Cretaceous, and even Jurassic and Triassic times.

On homotaxis.—The similarity of the fossil faunas of the Orient to those of the west coast of America is, indeed, surprising, but not more so than that of the living faunas of Japan and the Californian province. It is important in the correlation of these deposits to determine whether they are really synchronous. Ever since Huxley* cast doubt upon the simultaneous occurrence of the same faunas in widely separated regions, geologists have been inclined to assume that this similarity is good proof that they were not really synchronous. But we know that the present faunas of Japan and the Cali-

* Quart. Jour. Geol. Soc., London, xviii, 40–54, 1862.

fornian province are synchronous and similar, with many identical species, although they are in different geographic regions. And there is no more reason to assume that the similar Mesozoic faunas of the two regions were not synchronous than there is for the present time. The modern instance shows that they may just as well have been synchronous as not.

Biologists are often sceptical as to identity of species in separated regions in the past, on the ground that the criteria for determining fossils are not so exact as those applied to recent forms. But this is also fallacious, since the recent shells of Japan and California have been subjected to most careful examination by critical conchologists, and many species found to be identical. There is, therefore, no presumption against the identity of similar species in the two regions of Cretaceous, Jurassic, or even Triassic age.

On the permanence of the shore-line.—The marine sediments and their fossils around the North Pacific, from the Trias on to the present time, show that the shore-line has been, during all that time, approximately as it is now. There is no reason to theorize about great changes in physical geography, when such a simple matter as the periodic opening and closing of Bering Strait by rising and sinking of the land in that quarter will account satisfactorily for all the changes in character and distribution of the marine faunas. E. Haug,* in his studies of the distribution of Mesozoic formations and organisms, has invented the theory that during Mesozoic time a great continent existed where the Pacific Ocean now is. Whatever may be true of the rest of that ocean, there is no necessity for supposing a continent to have existed formerly in the North Pacific, when all the facts may be explained more easily on the hypothesis of the permanence of the shore-line approximately as it is now. This has nothing to do with the general proposition of the permanence of continental plateaus and oceanic basins, but merely proves a particular case, and suggests that some of the ancient oceans, that are to be found on maps purporting to represent the former continents and seas, may be only epicontinental seas.

* Les Geosynclinaux et les Airies continentales. Bull. Soc. Géol., France (3), xxviii, 646.

Stanford University, California.

Art. XXI.—*Triticites*,* *a New Genus of Carboniferous Foraminifers*;† by George H. Girty.

When, in the course of preparing a report on the Permian fauna of the Guadalupe Mountains, I came to study the species described by Shumard as *Fusulina elongata*,‡ my attention was engaged by a structural difference of some mark between it and the form from the Coal Measures strata of the Mississippi Valley, commonly identified as *Fusulina cylindrica*. I was consequently led to consider the structure of typical *Fusulina*, and found that the Guadalupian species, and not the common Pennsylvanian one, agrees with the Russian form. The discriminating character which is shown by Fischer-de-Waldheim's original figures of *Fusulina*, by specimens from Russia, and by most figures and descriptions in manuals,§ etc., resides in the partitions which separate adjacent chambers in the same concentric series.

As is well known, each chamber is formed by a narrow prolongation of the outer wall in the direction of revolution, followed by a sharp deflection toward the axis to meet the volution below. The partition thus formed is not, however, complete, minute apertures being left along its lower margin.‖ In true *Fusulina* this partition wall is strongly and regularly fluted in a radial direction, and the arrangement is such that the concave flexures of one partition are opposite the convex flexures of the next, the approaching curves coming in contact more or less precisely along a line. Thus what would otherwise have been a single long chamber extending unobstructed from end to end, is divided into a large number of chamberlets. These are usually quite regular and have the shape of prisms with subrhombic section. The regular fluting of the partitions is often well shown by the aperture, but no intimation of it is conveyed by the straight depressed sutures which prominently mark the external surface. Apparently the fluted structure is not introduced until just after the wall has assumed a radial direction, when it is concealed by the overlap of the succeed-

* From *triticum*, a grain of wheat.

† Published by permission of the Director of the U. S. Geological Survey.

‡ St. Louis Acad. Sci., Trans., vol. i, 1859, p. 388.

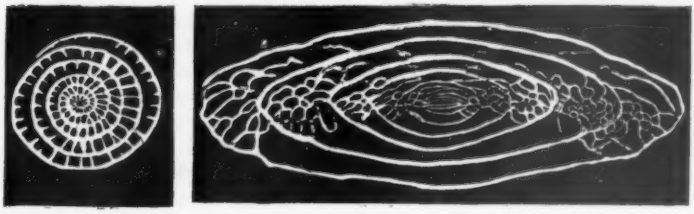
§ As, for instance, on p. 31 of Steinmann and Döderlein's Elemente der Paläontologie (Leipzig, 1890), on p. 104 of Zittel's Handbuch der Paläontologie, Bd. I (Munich and Leipzig, 1876–1880), on p. 32 of Zittel's Textbook of Palæontology (London and New York, 1896), on p. 136 of Nicholson and Lydekker's Manual of Palæontology, vol. i (Edinburgh and London, 1889), etc. See, also, Geology of Russia, etc., by Murchison, de Verneuil, and Keyserling, vol. ii, 1845, pl. i, fig. 1*e*.

‖ Indicated by the frequent failure of the partition walls to extend to the preceding volution.

ing wall. Let, however, the outer wall be removed by weathering or by artificial means, and the surface is seen to be very regularly divided into rhombs, which the eye naturally follows in spiral rows.

In the form from the Mississippi Valley for which the name *Triticites* is proposed, the partitions are for the most part straight, and not fluted except in the immediate vicinity of the axis, so that the greater portion of each chamber is not divided into chamberlets. There is also a slight formal difference between *Triticites* and *Fusulina*, since the former seems not to occur in the elongate subcylindrical shapes often found in the latter. *Triticites* is usually subglobose or spindle-shaped, but as *Fusulina* likewise develops these forms, configuration is of but limited importance in discriminating the two genera.

1 2



Transverse section. ×10. Longitudinal section. ×10.

Externally they will many times look almost precisely alike, except for the aperture, which, if exposed, will at once serve to distinguish them. In weathered specimens the long almost parallel lines of the partitions in *Triticites* are in marked contrast to the reticulation formed by these structures in *Fusulina*. Transverse sections in the two genera are sometimes nearly alike. In each case a spiral wall is seen from which in *Triticites* simple projections extend at regular intervals toward the center, reaching in some cases nearly, and in others completely, to the preceding volution. This is well shown by fig. 1, which represents *Triticites secalicus*. A transverse section through *Fusulina* presents a similar appearance, save that the partition walls are frequently represented by looped or forked lines, instead of by simple ones. The radial walls are seen in many cases to be incomplete, and it is probably by means of the apertures thus left that communication between succeeding chambers was maintained. In longitudinal section the difference is more apparent. The concentric walls of *Fusulina* enclose between them lines, sometimes straight, sometimes curved, often loop-shaped, which are the edges of the inter-

sected fluted partitions, the direction of which is seldom the same as that of the section. In longitudinal sections of *Triticites* there extends along the axial line a band of anastomosing walls, sometimes constituting a more or less regular network, but usually disordered and confused. Aside from this the space between the concentric walls over the median and larger portion of the volutions is uninterrupted, except as some irregularity permits the section to cut one of the longitudinal partitions. Fig. 2 represents a longitudinal section through *Triticites secalicus*. The undivided chambers are well shown in this section, and the wrinkled partitions near the ends of each chamber, which by their recurrence produce a band through the axis. This difference in longitudinal section would probably escape no trained observer, but its significance can be appreciated only when interpreted in terms of the complete organism.

The minute wall structure of *Triticites*, though it does not seem to differ from that of *Fusulina*, deserves to be noticed. The wall in these shells is composite, apparently consisting of two substances of different character, or, at all events, of different density. Thus, when thin sections are examined, three different tints, with more or less well-marked boundaries, are seen, namely, the transparent calcitic filling of the chambers, the translucent substance of which most of the wall is composed, and an outer opaque layer whose distribution will be described somewhat carefully. This opaque layer is much thinner than that which is translucent, and seems to represent merely an external coating upon the upper and front sides of each chamber wall. It usually appears as a strong dark line in thin sections, which defines the translucent wall of one chamber from that of the next, and it forms a plane of dehiscence along which the chambers and volutions tend to separate. A certain amount of variation is manifest by this layer and its conduct in the partitions is different from that in the revolving wall, an indication of individuality in these structures of which there is further evidence. In the revolving wall it occasionally happens, chiefly in local areas, that no intensification of tint is seen along the outer surface, the whole wall being practically uniform. In other instances an intensification occurs on the inner side nearly equal to that of the outer, but as a rule, from which exceptions are but few, sections clearly show a dark coating upon the outer surfaces of the revolving wall. This layer is seen to be continuous from the revolving wall to the partitions and it thus defines to the eye the limits of each chamber from that adjacent to it. The growth of the shell is, therefore, seen to be the result of a repetition of similar stages, each of which consisted of a prolongation of the shell first in a

revolving and then in an axial direction. While as a rule the dark line of the dense layer defines the external surface of the partition as well as of the revolving wall, the thick inner layer apparently being continuous from one to the other, occasionally it interrupts the latter and as it assumes an axial direction fans out and either divides, so as to bound both sides of the partition, or spreading, involves it in a nearly uniform dark tint. In this case obscure radial lines, probably of structural origin, can sometimes be made out. The partitions, as we shall shortly see, have otherwise a different structure from the revolving wall. The distribution and behavior of this dark coating seems to me to indicate that it is an original and intrinsic feature of the shell structure, and that it does not represent the contact between two walls nor the plane along which testaceous material was deposited from two sides. Somewhat in contradiction, however, stands the fact that where the walls have become detached the dark layer is often not conspicuously

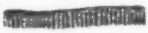
3

Transverse section.
×15.

4

Transverse section.
×25.

5



Microscopic structure.
×40.

retained upon either of them. Figs. 3 and 4, drawn from *Triticites secalicus*, show the general microscopic structure of the wall, the thin outer dense layer, and the thick inner translucent layer. They show the inner wall as completely surrounding the interior of the chamber. While not of rare occurrence, it is more common for the inner layer to be developed only on the upper and outer portions of the chamber wall, the lower and inner boundary being formed by the dense outer layer of the volution and chamber preceding. It is evident that the complete inner layer, if it is extended from end to end, would cut off all communication between adjacent chambers (except through the pores). The formation of this layer, therefore, over the back and lower walls is probably due to subsequent deposition.

Part of the translucent wall is thickly penetrated by opaque rods or tubuli, whose direction is normal to its two faces, and it is this structure which has caused *Fusulina* to be described as strongly perforate. These rods or tubes are always considerably darker than the translucent wall which they pervade and are as a rule of somewhat lighter tint than the dense outer layer. They usually increase in size inward and taper toward

the opaque layer, and while in some instances they reach and connect with the latter, for the most part they diminish and disappear before completely penetrating the translucent wall. They have the same appearance whether the specimen is cut lengthwise or transversely, and their cross section was probably circular. In their distribution these rods or tubes seem to be confined entirely to the revolving wall. Occasionally they can be seen to extend part way around the turn to where the wall becomes radial, but I have never seen them in the partition wall itself. Fig. 5 represents a section through part of the revolving wall of *Triticites secalicus*. The upper margin of the figure is the outer margin of the wall. The dark lines represent what has usually been interpreted as pores or tubes. These structures can not be seen in the radial walls.

In section, therefore, the revolving wall is seen to be barred off into nearly equal stripes of opaque and translucent shades, and of these it is clear that the translucent ones represent the shell and the opaque ones what have been considered pores.

Carpenter described the minute structure of "*Fusulina*" in 1870, and his conclusions have been followed or concurred in by most subsequent writers. It is interesting to note that his investigations were made upon specimens from Iowa which with great probability belonged not to *Fusulina* but to *Triticites*. One can hardly doubt that he also studied specimens of real *Fusulina*, and it is difficult to understand why he disregarded the differences which have led me to distinguish *Triticites* as a distinct group. Though he does not mention or figure the dark layer which coats the walls upon their outer side and which in sections defines the outline of each chamber, and though other writers have not, whose work has come into my hands, I am quite satisfied as to its existence and persistence.* The interpretation of its significance, on the other hand, is a matter of uncertainty. The presence and conduct of this dark superficial layer and its relation to the so-called tubuli have led me to entertain some doubt as to whether the shell in this genus is as usually stated, perforate.

Carpenter remarks upon the complexity of the partition walls in the terminal portions of *Triticites* in the following terms: "The irregularities which are noticeable in *sections* made either longitudinally or traversely through the terminal portions of the shell, seem explained by the disposition of the alar prolongations which is revealed by *fracture;* for this shows that the alar prolongations, as they pass to a distance from the median plane, tend to interdigitate with each other,

* Material of both *Fusulina* and *Triticites* has been examined, and from a number of localities and horizons sufficient to show that these characters are constantly present and are not the result of peculiar preservation.

in such a manner as to produce great apparent confusion when they are brought into view by section."* While this is perhaps equally true of *Fusulina*, the simplicity of the partitions in *Triticites* over their median portion renders their complexity near the ends peculiarly striking. From the passage above quoted, from Carpenter's figures, and from the localities and horizons from which his American specimens were obtained, there can be no doubt that they belonged to *Triticites*, instead of to *Fusulina*.

I am in some uncertainty about the taxonomic value which should be given to the differences above noted between *Fusulina* and *Triticites*. It is evident that they are of degree only, though very marked in the case of the forms under discussion, intermediate stages being unknown. I would regard *Triticites* in any other group as a good subgenus, though probably no more; but among forms whose simple structure puts a certain limit upon differentiation, it seems that somewhat different standards should be employed, and I believe that the group of *Triticites* can be given generic rank.

The type of *Triticites* is not a new species. In 1823 Say† described two species from Kansas and Nebraska under the name of *Miliolites secalicus* and *Miliolites centralis*, which from evidence intrinsic and extrinsic belong without question to the group of fossils for which the name *Fusulina cylindrica* has since come into general use. J. W. Beede‡ was, I believe, the first to recognize the real character of *Miliolites secalicus* and to revive this specific name for the American form, but he did not discriminate it from *Fusulina cylindrica* Fischer-de-Waldheim, which he relegated to synonymy. While I had little doubt that the American species was distinct from the Russian one, I have continued to use for it the name *Fusulina cylindrica*, because it seemed to me undesirable to disturb the current terminology until several essential points could be determined with reasonable finality. In the present paper I have sought to show that the American form is not only specifically distinct from *Fusulina cylindrica*, but can probably be referred to a different genus, for the type of which *Triticites secalicus* is selected. This species was first described from the Missouri River near the Platte. The material upon which my interpretation of *Triticites secalicus* is based, and upon which the term *Triticites* immediately rests, was obtained from the Platte River near its junction with the Missouri. The locality and horizon, therefore, can be said to be essentially the same,

* Monthly Microscop. Jour., vol. iii, 1870, p. 182.

† Account of an Expedition from Pittsburgh to the Rocky Mountains, etc., under Major Stephen H. Long, vol. i, 1823, p. 151, footnote.

‡ Univ. Geol. Surv. Kansas, Rept., vol. 6, 1900, p. 10.

and as my material agrees with Say's description as far as it goes, I have little doubt that it is the same species for which the name was first employed. My investigations have been carried sufficiently far to show that most if not all of the so-called *Fusulinas* of the Mississippi Valley belong to *Triticites*. I am not prepared to express an opinion as to whether several or, as has generally been assumed, but a single species occurs there. The second species described by Say, under the name of *M. centralis*, is doubtfully distinguished by the characters pointed out by its author. Say's description of *Miliolites secalicus* is framed in the following words, and can be amplified from the descriptions and figures here presented:

"29. On the Missouri near the Platte occur masses of rock, which seem to be almost exclusively composed of a remarkable petrifaction, belonging to the family of concamerated shells. This shell is elongated, fusiform, and when broken transversely, it exhibits the appearance of numerous cells disposed spirally as in the *Nummulite*, but its longitudinal section displays only deep grooves. The shell was therefore composed of tubes or syphons, placed parallel to each other, and revolving laterally as in the genus *Melonis* of Lamarck, with which its characters undoubtedly correspond. But as in the transverse fracture, its spiral system of tubes cannot be traced to the center in any of the numerous specimens we have examined, it would seem to have a solid axis, and consequently belongs to that division of the genus that Montfort regards as distinct, under the name of *Miliolites*, which seems to be similar to the *Fasciolites* of Parkinson, and altogether different from the Miliolites of Lamarck. Our specimens are conspicuously striated on the exterior, which distinction, together with their elongated fusiform shape, sufficiently distinguish then as species from the *sabulosus* which Montfort describes as the type of his genus. No aperture is discoverable in this shell, but the termination of the exterior volution very much resembles an aperture as long as the shell.

The length is three-tenths of an inch. And its greatest breadth, one-twelfth.

We call it *Miliolites secalicus, Say.* Mr. T. Nuttall informs me, that he observed it in great quantities high up the Missouri.

In the same mass were some segments of the Encrinus, and a Terebratula with five or six obtuse longitudinal waves."

Art. XXII.—*Prismatic Crystals of Hematite;* by G. W. McKee.

The common forms for hematite crystals are rhombohedra and scalenohedra. Prismatic faces are seldom well developed. The basal pinacoid is still rarer. Specimens of well crystallized hematite showing crystals of an unusual habit were obtained recently from Dr. A. E. Foote, Philadelphia. These specimens are reported to be from Guanajuato, Mexico. The crystals, which are very small, seldom more than a millimeter in diameter, are well formed and possess a bright metallic lustre such as is characteristic of the specimens from Elba. They occur spread in a layer over the surface of a much decomposed rock, which is probably a rhyolite.

A few of the best crystals were selected for measurement on a Goldschmidt two-circle reflecting goniometer. Some of

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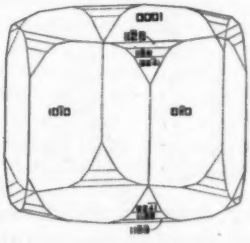


them showed combinations of the prism $\{10\bar{1}0\}$ and base $\{0001\}$, while others presented in addition to these forms several pyramids of the second order. In all cases, however, the most prominent forms were the prism $\{10\bar{1}0\}$ and the base $\{0001\}$. These faces ordinarily play a very subordinate part in the crystallization of hematite and by their prominence here we obtain a distinct prismatic crystal habit hitherto rarely recorded for hematite. The results of the measurements on two crystals are given in detail and along with them, for purposes of comparison, the calculated results for the symbols deduced. If we consider the pyramids as of the second order then the prism becomes the prism of the first order. All the forms observed here are already well known, the complete list being as follows:—$\{0001\}$, $\{10\bar{1}0\}$, $\{11\bar{2}8\}$, $\{11\bar{2}2\}$, $\{22\bar{4}1\}$.

CRYSTAL No. I.

No.	Measured. ρ	Measured. ϕ	Calculated. ρ	Calculated. ϕ	Symbol.
1	0°	----	0°	----	{0001}
2	90°	0° 15′	90°	0°	
3	90°	0° 2′	90°	0°	
4	90°	0° 8′	90°	0°	{10$\bar{1}$0}
5	90°	0° 15′	90°	0°	
6	90°	0° 10′	90°	0°	
7	90°	0° 8′	90°	0°	
8	72° 21′	29° 52′	72° 22′	30°	{22$\bar{4}$1}
9	38° 36′	28° 2′	38° 11′	30°	
10	37° 15′	27° 46′	38° 11′	30°	
11	38° 24′	30° 25′	38° 11′	30°	{11$\bar{2}$2}
12	37° 15′	30° 40′	38° 11′	30°	
13	40° 6′	28° 55′	38° 11′	30°	

CRYSTAL No. II.

No.	Measured. ρ	Measured. ϕ	Calculated. ρ	Calculated. ϕ	Symbol.
1	0°	----	0°	----	{0001}
2	90°	0° 14′	90°	0°	
3	90°	0° 2′	90°	0°	
4	90°	0° 17′	90°	0°	{10$\bar{1}$0}
5	90°	0° 3′	90°	0°	
6	90°	0° 1′	90°	0°	
7	72° 22′	29° 31′	72° 22′	30°	
8	72° 22′	29° 45′	72° 22′	30°	{22$\bar{4}$1}
9	12° 30′	29° 45′	11° 7′	30°	{11$\bar{2}$8}

The accompanying drawing, fig. 1, was prepared from a gnomonic projection showing the projection points of the normals of an idealized crystal representing all the forms obtained. The relative central distance for the different forms indicated in the drawing corresponds very closely with that of the crystals examined.

Hematite crystals showing the prismatic habit have been described by Pirsson.* His specimens were also obtained from Mexico and were peculiar in their association with cassiterite, which was frequently contained in the hematite as inclusions. Some of the Guanajuato crystals were finely powdered and treated with hot concentrated hydrochloric acid; the resulting solution was tested in the usual method and was found to be free from tin.

These observations were made in the Mineralogical Laboratory of the University of Toronto.

* This Journal, vol. xlii, pp. 407, 1891.

Department of Mineralogy, University of Toronto,
December, 1903.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *An Attempt at a Chemical Conception of the Universal Ether.*—D. J. Mendeléeff, the celebrated author of the Periodic System of the Elements, has published some speculations in regard to the ether.

From a realistic standpoint it is inevitable that weight and chemical individuality should be ascribed to the ether. It must be a distinct chemical substance so light that it can escape the attraction of the fixed stars by the swiftness of the motion of its molecule; it can have no chemical affinity; its power of diffusion must be so great that it can penetrate all bodies, and thus elude being weighed, although it actually possesses a very minute weight. It can be assumed to be an inactive gas of the argon-helium series with very small atomic weight. By means of *inter*polation the author has predicted new elements (scandium, gallium, and germanium), and he ventures to make *extra*polations below helium. In the place before hydrogen he assumes the existence of an inactive element, which possibly is identical with *coronium*, with an atomic weight estimated at about 0·4. The ether must have a still smaller atomic weight, the value of which, $<0{\cdot}17$, on account of the double extrapolation, is very uncertain. For the ether as an element the author proposes preliminarily the name *Newtonium*. He calculates also, that, in order that it might escape from the largest bodies of the universe, the atomic weight of the ether might necessarily be as small as one-millionth of that of hydrogen.

The author gives, in addition, a realistic explanation of radio-activity by supposing that the radio-active elements (U, Th, Ra) on account of their abnormally high atomic weights are capable of holding a relatively large number of the ether atoms about their large centers of mass, without combining with them chemically, and that the arrival and departure of the ether molecules is accompanied by disturbances in the ethereal medium which produce the rays of light.—*From an abstract in Chem. Central-Blatt*, 1904, i, 137. H. L. W.

2. *Gold Fluoride.*—Since gold frequently accompanies fluor-spar in natural deposits, it seemed possible that gold fluoride might play a part in the formation of such deposits. Therefore, Victor Lenher has undertaken a study of the relations of gold and fluorine. Finely divided oxide of gold was found to be entirely unattacked by hydrofluoric acid, even in the presence of nitric acid. It was found to be impossible to prepare gold fluoride by the interaction of silver fluoride and gold chloride, for the substances reacted as follows:

$$AuCl_3 + 3AgF + 3H_2O = 3AgCl + Au(OH)_3 + 3HF.$$

Since it seemed that water decomposed gold fluoride as soon as it was formed, attempts were then made to carry out the same reaction in the presence of anhydrous solvents, such as ether, chloroform, carbon tetrachloride, etc., but the substances under experiment were either insoluble in these solvents, or were decomposed by them, so that this method did not succeed. Gold fluoride appears, therefore, incapable of being formed by ordinary reactions, although Moissan, by the action of fluorine gas upon gold at a red heat, obtained a yellow, hygroscopic substance which easily decomposed into the metal and fluorine. It is remarkable that fluorine, the most active of all the elements, should have so slight an affinity for gold.—*Jour. Amer. Chem. Soc.*, xxv, 1136.

H. L. W.

3. *The Separation of Radium from Barium.*—Heretofore the only available method for obtaining products richer in radium from mixtures of barium and radium salts, has been the fractional crystallization of the chlorides or the bromides. Marckwald has now found that it is possible to obtain an enrichment in radium by agitating a concentrated solution of the salts with one-fifth of its weight of one per cent sodium amalgam. Barium and radium amalgam is thus formed in which the proportion of radium is much increased over that in the original mixture. By repeating the operation with the residual liquid, after it has been previously neutralized, successive products are obtained which gradually diminish in activity. The method as thus employed offers no advantages over the method of fractional crystallization, since it also is a fractionating process, but it is interesting in showing for the first time a difference in chemical behavior between barium and radium.—*Berichte*, xxxvii, 88. H. L. W.

4. *The Dissociation of the Alkaline Carbonates.* — Having previously shown that lithium carbonate can be completely volatilized in a vacuum above 1000° in consequence of its dissociation into carbon dioxide and lithium oxide, P. Lebeau has studied the behavior of the carbonates of sodium, potassium, rubidium and cæsium under the same conditions. He has found that all of these carbonates are dissociated above 800° with the formation of carbon dioxide and a volatile alkaline oxide, so that a sort of volatilization of the carbonates takes place. When the alkali metals are divided into two sub-groups, lithium and sodium comprising the first, and potassium, rubidium and cæsium the second, it found that the ease of dissociation decreases with the atomic weight in the first sub-group, and increases with it in the second. —*Comptes Rendus*, cxxxvii, 1255. H. L. W.

5. *Combination of Saccharose with Certain Metallic Salts.*— It is known that cane-sugar unites with sodium chloride, bromide and iodide, as well as with potassium chloride, to form crystalline compounds. D. Gauthier has recently succeeded in obtaining a number of other similar compounds which are well-defined. The following substances are described :

$C_{12}H_{22}O_{11}\cdot KI\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot LiCl\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot LiBr\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot LiI\cdot 2H_2O$
$C_{12}H_{22}O_{11}\cdot CaBr_2\cdot 3H_2O$
$C_{12}H_{22}O_{11}\cdot CaI_2\cdot 3H_2O$
$2C_{12}H_{22}O_{11}\cdot BaCl_2$
$2C_{12}H_{22}O_{11}\cdot BaBr_2$
$2C_{12}H_{22}O_{11}\cdot BaI_2$

It is proposed to study the properties of these bodies in the future, and also to attempt the preparation of compounds with other salts.—*Comptes Rendus*, cxxxvii, 1259. H. L. W.

6. *The Density of Chlorine.* — New determinations of the density of chlorine gas have been made by Moissan and Jassoneix. The method of Dumas was employed, which consists in filling a globe having a slender neck with the gas, by displacement, sealing the neck by fusion, and weighing. Considerable difficulty was experienced in obtaining pure chlorine ; even liquid chlorine was found to hold other gases in solution, and the best results appear to have been obtained by using chlorine which had been previously solidified by cooling. As an average of the best results, the density 2·490 at 0° is given. This number agrees very closely with Leduc's result, 2·491, published in 1897.—*Comptes Rendus*, cxxxvi, 1198. H. L. W.

7. *The Doppler Effect in Electrical Sparks.*—If metallic particles are torn off from the electrodes between which a spark is produced and are lighted, one would expect on looking in the direction of the spark with a suitable optical arrangement to see, according to Doppler's principle, a displacement of the lines of the spectrum. Aug. Hagenbach uses two sparks in front of the slit of a spectroscope. The current was directed through these gaps in opposite directions. In one experiment Michelson's echelon spectroscope was used with mercury lines. The results were negative; and the author concludes that there is no displacements greater than 0·01 A.-unit ; if the Doppler principle holds for the case of electric sparks, the velocity of the metallic particles cannot be greater than this value indicates. In another experiment a Rowland grating was used and a similar result was reached. The author's results do not agree with those obtained by Schuster and Hemsalech, or with those of Mohler, in regard to the velocity of the shot off particles. These authors found a large velocity for such particles.—*Ann der Physik*, xiii, pp. 362–374. J. T.

8. *Effect of Temperature on Ionization by Röntgen Rays.*—R. K. McClung, working in the Cavendish laboratory, believes that he has proved conclusively that, in a given volume of gas, kept at a constant density, the amount of ionization produced by Röntgen rays of a given intensity is independent of the temperature of the gas.—*Phil. Mag.*, 1904, pp. 81–95. J. T.

9. *The Arc in Metallic Vapors in an Exhausted Space.* — Dr. E. WEINTRAUB has conducted, in the laboratory of the General Electric Company at Schenectady, an exhaustive series of experiment on the Cooper-Hewitt mercury lamp.

(1) By a series of experiments it was shown that in the process of starting an arc the cathode plays an important role, so that a certain change must take place on its surface before the arc can start; the anode receives the current without any previous excitation.

(2) Starting from the recognition of this role of the cathode, a new method has been devised for an instantaneous starting of the passage of a moderate voltage current through the space separating the electrodes, and this no matter how long this space is.

(3) The properties of the mercury arc have been studied, and a number of differences in the behavior of the cathode and the anode, beside the one mentioned above, stated.

(4) The behavior of amalgams, as well as pure alkali metals, has been investigated, and the complete analogy between the behavior of the arc in their vapors and that of the mercury arc shown.

(5) Different ways have been found to cause an alternating current to pass through mercury vapor in form of an arc.

(6) On the basis of this a theoretically almost perfect rectifier for conversion of alternating current into steady direct current was developed.—*Phil. Mag.*, Feb., 1904, pp. 95–124. J. T.

10. *Electricity and Magnetism. An Elementary Text-Book Theoretical and Practical;* by R. T. GLAZEBROOK. Pp. viii + 440. Cambridge, 1903 (The University Press).—This volume, like the others by the same author in the Cambridge Physical series, is based on the first year work in physics as given at the Cavendish laboratory. Also, like its predecessors, it is a type of text-book little used in this country. The ordinary method of carrying on instruction in physics is threefold; first, by means of a lecture course, second, by laboratory work, and third, by a quiz. As an aid to the two latter branches, the common practice in this country is to provide the student with two separate text-books—one treating the theory of the subject from a general standpoint and the other containing directions more or less minute for a certain number of experiments. On the other hand, the English practice, as exemplified in the book before us, is to combine the two books into one. That this method has certain advantages in giving the student a better perspective is obvious; and that this view is coming to be more appreciated here, is evidenced by the volume on Mechanics and Heat which has recently appeared from the Ryerson laboratory at Chicago. (See below.)

The development of the doctrines of electricity and magnetism, together with their more important applications, is carried out admirably along the lines which Maxwell made classic. The experiments are well chosen and numerous examples are scattered

through the book to aid in driving the principles home. The most recent developments in the science also receive adequate attention, the last two chapters being on Hertzian waves and the recent work on the discharge through gases. The demonstrations and deductions are often of the unsatisfactory nature which the necessity of excluding the Calculus makes unavoidable. But aside from this defect, which is inherent in any presentation written for students in a like state of mathematical ignorance, this book appears to the writer to be the most satisfactory one that has come under his notice. L. P. W.

11. *Mechanics, Molecular Physics and Heat.* A Twelve Weeks' College Course; by R. A. MILLIKAN. Pp. 242. New York, 1903 (Ginn & Co.).—This book is a combined text-book and laboratory manual. It represents an attempt to attain a closer coördination between the laboratory, the class room, and the lecture room, and as such is to be highly commended. No one who has taught elementary Physics can fail to be in sympathy with this aim or to be interested in the way in which the problem is attacked in the Ryerson Laboratory. The writer can recommend the preface of this book to all who are interested in the very serious problem of how best to teach Physics.

Judging from personal experience with students of the maturity implied, it would seem as if too much knowledge were assumed. Neither velocity nor mass are explicitly defined. The logical sequence of the development of the principles of mechanics is not all that could be desired. On the other hand, the selection and arrangement of the experiments and problems is excellent. On the whole it would seem that while the book is well adapted to the system of instruction in use at Chicago, its usefulness elsewhere will be limited—unless that system comes to be generally adopted. L. P. W.

12. *Treatise on Thermodynamics;* by MAX PLANCK. Translated by ALEXANDER OGG. Pp. xii + 272. New York (Longmans, Green & Co.).—This is an excellent translation of Professor Planck's well-known work on thermodynamics which appeared in 1897, embodying in a connected treatment of the subject the author's many original contributions to this branch of science. Like all of Planck's work, it is marked by strict and satisfactory logical development and by a clear recognition of the nature, authority and limitations of our knowledge of the general principles upon which the science is based. The treatment of the Second Law, while essentially the same as that employed by Clausius, Kelvin and Maxwell, is, at the same time, original in its point of view and is very illuminating; it should not be neglected by any serious student of thermodynamics. Irreversible processes receive a larger share of attention than is usual—a most commendable feature in a text-book since all actual thermodynamic processes are irreversible, and it is, therefore, very essential that the knowledge of the working physicist and engineer should not be confined to the ideal reversible case. The book also gives a large amount of space to the discussion of the applications of thermodynamics to the problems of chemical equilibrium and it should

be very useful to the student of physical chemistry. From the pedagogical point of view, one could wish that the author had not confined himself so strictly to analytical methods and that more diagrams and geometrical illustrations had been employed; but after all this is largely a question of taste. H. A. B.

II. Geology.

1. *The Coral Reefs of the Maldives;* by Alexander Agassiz. Mem. Mus. Comp. Zool. Harvard College. Pp. i–xxv, 1–168, 82 pls. One volume text. One volume plates.—Parts of December, 1901, and January, 1902, was spent by Professor Agassiz in exploring the Maldives (for sketch of the work of this expedition see this Journal, xiii, 297). All of the important atolls were examined and more than eighty soundings were taken. The variety exhibited by the small islands points "to the uselessness of our present definition of atolls. There is every possible gradation between a curved crescent-shaped open bank of greater or less size and an absolutely closed ring of land surrounding a lagoon without direct communication with the sea. The evidence . . . shows that reef corals will grow upon any foundation where they find the proper depth and that local conditions will determine their existence as fringing reefs, barrier reefs or atolls." In most particulars the work of Gardiner is substantiated (this Journal, xvi, 203), but the soundings reveal considerable irregularity in the depth of the plateau, and the conclusions drawn by Gardiner from the supposed existence of a great level central plateau may need revision. The soundings show also that Darwin's suggestion that the Maldive Archipelago originally existed as a barrier reef of nearly the same dimensions as that of New Caledonia, is not borne out.

This is the last of a series of monographs on Coral Reefs, but Professor Agassiz promises a *résumé* of results obtained from study of all the important coral regions of the Atlantic, Pacific and Indian Oceans.

2. *Note on the Classification of the Carboniferous formation of Kansas;* by Henry S. Williams. (Communicated.) — In the brief review of Bulletin 211 of the U. S. Geological Survey (this Journal, xvii, 175), a few facts were not given which perhaps should be stated in order to give credit where credit is due, and the quotation on p. 176 is by its incompleteness somewhat misleading, hence the following statement:

A further examination of Bulletin No. 211 of the United States Geological Survey shows that the following formations, viz: Elmdale, Neva, Eskridge, Garrison, Matfield, and Doyle had previously been given these names by Prosser and Beede and were more fully described by Prosser. Their description was published by Prosser in the Journal of Geology, vol. x, pp. 708–715, which number appeared during the first week of December, 1902, eleven months before the publication of Bulletin No. 211.

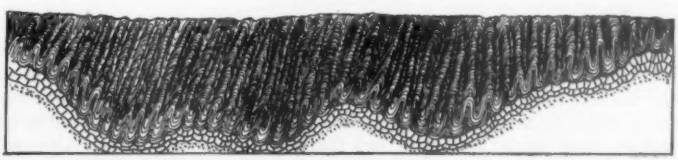
Mr. Girty stated that "the evolution of the latest from the

earliest faunas in the section" is shown "to have been a progression from a brachiopod to a pelecypod facies. The gradual character of this replacement has been remarked by most paleontologists who have studied the faunal succession. It is without marked interruption at any point, so that subdivisions appropriate for recognition are not clearly apparent, and there is room for differences of opinion as to where delimitation should be made."

3. *Einführung in die Paläontologie;* von Dr. GUSTAV STEINMANN. Pp. 1–466, figs. 1–818. Leipzig, 1903 (Wilhelm Engelmann).—This elementary treatise on paleontology is written by one of the authors of the "Elemente der Paläontologie" of Steinmann and Döderlein published in 1890, and appears to be an abbreviation and revision of that work, using the same illustrations, with an addition of fifty pages on fossil plants, and numerous new figures. The reduction of a work attempting to introduce the reader to a knowledge of plants and animals of past geological time to 466 pages, makes it necessary to mention only the more conspicuous families, while for each family only the more characteristic are named and very brief descriptions given. It is too technical for general reading and not complete or full enough to be of much use in the laboratory, but it may serve as a means of gaining a superficial knowledge of the names of the more conspicuous genera met with in treatises on geology and thus be of use to the geologist or general student as a means of gaining definite ideas of the forms of fossils. It is well printed and the illustrations are chosen to give a comprehensive idea of the diagnostic characters of the forms illustrated. H. S. W.

4. *The Structure of the Piedmont Plateau as shown in Maryland;* by EDWARD BENNETT MATHEWS.—Attention is called to the fact that fig. 1, p. 150, in the article by E. B. Mathews, is printed in inverted position. The figure is here repeated inserted in its correct position.

1



5. *Western Australia Gealogical Survey.* — Three bulletins have recently been issued as follows:

No. 8. Lennonville, Mount Magnet, and Boogardie, Murchison Goldfield; by CHAS. G. GIBSON. 33 pp. with map.

No. 9. Geological Features and Mineral Resources of Northampton; by A. GIBB MAITLAND. 28 pp. with map and sections.

No. 10. Descriptions of Carboniferous fossils from the Gascoyne District, Western Australia; by R. ETHERIDGE, JR., 41 pp. 6pls.

6. *The Evolution of Earth Structure;* by T. MELLARD READE. 342 pp., 40 pls., 1903. (Longmans, Green & Co.)—In this volume Mr. Reade has brought together his views upon the causes of crustal movements. The volume falls naturally into two divisions, first the causes of broad vertical movements without tangential thrust, commonly known as epeirogenic; and secondly, the causes of tangential thrusts and their relations to mountain building.

However much geologists may differ from some of the conclusions of the work, the author's method must be regarded as admirable, first presenting generally conceded facts, secondly, framing a hypothesis and, thirdly, showing its mechanical possibility. Thus it may be said that Mr. Reade has developed true causes, but it remains to be seen from further study and generalizations if they are quantitatively sufficient, or if there are other more potent factors. Especially would possible changes of view upon the nature of the earth's interior modify his conclusions.

Taking up the first division of the volume, that concerning vertical crustal movements, Reade cites familiar examples of coastal oscillations and shows the incompetence of the principle of isostacy to initiate such movements or to give them an oscillatory character. The author maintains that isostatic equilibrium is true as a broad principle, as shown by the fact of the specific gravity of the continental crust and subcrust being less than that beneath the oceans, but relates this to diastrophic movements by assuming that slight regional changes of volume but not of mass occur deep within the earth.

Lateral shiftings within the earth would also result in such movements, but no cause has been shown why within a solid earth matter should so shift, especially as work would be done in lifting the continental masses. In favor of the view that the movements are due to slight volume changes without changes of mass or lateral shifting, Reade discusses the irregular changes of density which take place during the cooling of a bar of iron and the change in density due to magnetization.

The author believes that most of the fluctuations of volume take place within a depth of 500 miles from the surface in what he terms the "sphere of igneous magma" and "the condition of the matter may be normally solid, but potentially fluid, or actually fluid when nearing the surface." Following this statement of causes, the view is expressed from a consideration of the sea coasts that the continents as a whole are at present in an era of low level. An examination of the infrequency of deep sea soundings and the discovery of occasional rapid variations in depth leads to the further conclusion that there is merely negative evidence for the prevalent belief in the smoothness of the ocean floor and the permanence of continents, but that in regions removed from rapid sedimentation more careful soundings may reveal bottoms which still show forms of subaerial erosion. A considerable degree of impermanence of continents is further shown by a consideration of basins of sedimentation, and as bearing upon this problem two previous papers, "Denudation of the Two

Americas" and "The North Atlantic as a Geological Basin" are reprinted.

Turning to the author's views on orogeny, the belief is expressed that periods of mountain-making are related to the formation of new land areas, the orogenic cause consisting in alternate expansions and contractions, and being essentially that developed in his volume "The Origin of Mountain Ranges," 1886. Further details are added, however, giving the results of laboratory experiments upon models of various forms. These show how with circumferential compression strata may be folded into parallel crescentic or radiating crescentic folds with minimum mass deformation of the beds. The resulting forms are developable surfaces, made by simple bendings of the strata. An initial bias is shown to be an important factor in determining the form of yielding, and the whole is an important contribution showing the effects of compression acting in two or more directions simultaneously.

While Reade has demonstrated the adequacy of repeated expansions and contractions in producing deformations in several substances, notably to the distortions of a lead-lined sink, to the reviewer's mind it is far from being demonstrated quantitatively sufficient to result in mountain-making, chief among the objections being first, that there is no evidence of the numerous widespread fluctuations of internal temperature which would be necessary for the amount of shortening shown in the chief mountain ranges; secondly, that the unequal heating of higher and lower beds would result in differential movement and friction in transmitting the thrust to a distance, lessening the effective thrust of the expanding stratum and tending to produce local vertical mass deformation rather than distant folds. Thirdly, this theory does not account for the deferment of mountain-making for millions of years, during which time progressive sedimentation and subsidence is going forward, followed by a relatively brief epoch of crustal yielding.

In the latter part of the book the author devotes two chapters to faulting and to slaty cleavage. J. B.

III. Miscellaneous Scientific Intelligence.

1. *Smithsonian Institution*, S. P. Langley, Secretary, *Report for year ending June 30, 1903.*—The annual report of the Smithsonian Institution gives a summary of the work done in the several fields of activity. In the appendixes to the general report are more detailed statements regarding work of the National Museum, the Bureau of Ethnology, etc. The Museum is to have a $3,500,000 building in which its large and rapidly increasing collections may be properly stored. The Astrophysical Observatory has made special bolographic studies of the absorption of the solar rays. The atmosphere "has been more opaque than usual within the present calendar year, so much so as to reduce the direct radiation of the sun at the earth's surface by about 10 per cent throughout the whole visible and infra-red spectrum, and by more than double this amount in the blue and

violet portions of the spectrum." A new determination of the temperature of the sun gives 5920° C. For the study of sun spots, a horizontal reflecting telescope of 140 foot focus and 20 inch aperture, provided with a new form of coelostat, has been constructed.

2. *Smithsonian Miscellaneous Collections, Quarterly Issue.* Vol. I, Pts. 1 and 2.—The Quarterly issue of the Smithsonian Miscellaneous Collections is designed to afford a medium for early publication of the results of researches conducted by the Institution and for reports of a preliminary nature. The Quarterly Issue will not supersede but will form part of the regular series of the Smithsonian Miscellaneous Collections. It will be published about the first of January, April, July and October. Each number will consist of about 144 pages and will be suitably illustrated. The present number contains seventeen articles, among them the description of the new telescope and coelostat, by C. G. ABBOTT, mentioned in Secretary Langley's report (see above).

3. *Weather Bureau, U. S. Department of Agriculture.*—The two following volumes have recently been issued :

BULLETIN L. Climatology of California ; by ALEXANDER G. MCADIE. 261 pp., 31 figs., 12 pls. The great variety of climates existing within California and the numerous abnormalities exhibited, e. g., at San Francisco, makes the description of the meteorological conditions within the State of more than local importance. Professor McAdie discusses the controlling climatic factors of the Pacific Coast region, after which come descriptions of conditions prevailing in different parts of California. The chapter on Fog is particularly valuable, as the conditions at San Francisco are unusually favorable for the study of this phenomenon.

BULLETIN No. 33. Weather Folk Lore and Local Weather Signs ; by EDWARD B. GARRIOTT. 183 pp., 21 pls. Many of the everyday sayings regarding weather signs are true and have come from careful observation on the part of sailors, farmers and other men. Many weather proverbs, on the other hand, are ridiculous. Professor Garriott has classified and discussed these sayings and gives the true weather signs for 143 stations within the United States.

4. *Scientia*, No. 22. — The latest addition to this valuable series is entitled : Diagrammes et Surfaces Thermodynamiques, par J. W. Gibbs. The translation was made by M. G. Roy of the University of Dijon and an introduction is given by M. B. Brunhes of the University of Clermont.

OBITUARY.

Dr. CHARLES EMERSON BEECHER, Professor of Paleontology in Yale University, died suddenly of heart failure on February 14, in his 47th year. A biographical notice will appear later.

Professor KARL ALFRED VON ZITTEL, the eminent paleontologist of the University of Munich, died on January 6, at the age of 65.

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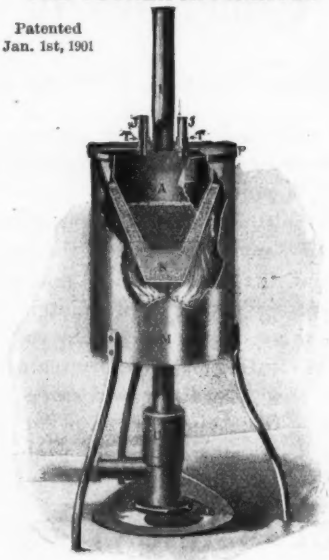

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